INVESTIGATIONS OF INDIANA LAKES

2. The Rate of Growth of Fishes of Indiana

BY

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3. The Lakes of Northeastern Indiana

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WILL SCOTT

THE DEPARTMENT OF CONSERVATION
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RICHARD LIEBER
DIRECTOR

GENERAL INTRODUCTION

The two papers which form this report are the second and third of a series reporting the results of studies on Indiana lakes and streams. These studies are made possible by the coöperation of the Division of Fish and Game of the Department of Conservation and the Biological Station of Indiana University.

There are two sorts of problems that arise: those which are particular, immediate, and often acute, and those which are general and fundamental. A hatchery becomes infected. The cause must be determined and a remedy developed. This is a good example of the first type of problem. Such problems must be and are attacked when they arise. However, it is much more important in the long run to determine the basic fundamental things. It is another case of "the longest way around is the shortest way through."

Our streams and lakes are no longer natural primitive bodies of water. Most of our lakes have many cottages on their shores from which directly or indirectly organic material reaches the lake. The fish are much more intensely harvested than formerly. It does not follow that a lake produces less fish than it once did because it contains less than it did formerly. When the Indians fished our lakes, these lakes undoubtedly contained many fish, but it is doubtful whether as many fish were taken from any lake during that period as are now taken from the same lake every year.

We do not know what the fish population of any lake is or what it normally should be. In general it may be said the more zoöplankton the more fish, but we know nothing of the details of this relationship.

Our only knowledge of the kind or amount of food a fish eats comes from stomach examinations. We know that certain fish eat cladocera, but we have no notion how much a given blue gill eats in a day, a week, or a season. We know how many cladocera are present on a given date in a lake, but the amount of them produced in a lake in a season cannot even be surmised. The cladocera present are the breeding stock. It seems trite and almost nonsensical to say that the cladocera that have been eaten are not present but much of the discussion of the production of plankton or fish food in a lake disregards the above fact.

For instance, Hogback Lake has a large cladoceran fauna, while Clear Lake has much less. It does not follow that Hogback Lake is producing more fish than Clear Lake. It may quite as easily be that Hogback Lake is insufficiently or improperly stocked, while Clear Lake has more nearly the proper balance.

These studies are the result of an attempt to lay a sound foundation of scientific data upon which ultimately may be built correct procedure in the development of our aquatic resources.

In the present number, the paper by Hile is a study of the growth rate in several of our common species of fish based on the examination of over 1,900 speciments. The paper by Scott is a study of the lakes of four counties of northeastern Indiana. A statement of the nature of this paper is given in its introduction. While no attempt has been made to make the discussion popular, I think the results may be understood by any intelligent, interested person.

WILL SCOTT.

II.
THE RATE OF GROWTH OF FISHES OF INDIANA

by

RALPH HILE

TABLE OF CONTENTS

INTRODUCTION

In attempting to arrive at some idea of the productivity of lakes, it is necessary not only to have quantitative data concerning physical and chemical conditions and the amount of food available as plankton and as bottom fauna, but it is also essential to possess information concerning the growth rates of the end products of production, the fishes. It is important to know the extent of the variation of this growth in different lakes, and to detect, if possible, any correlation existing between such variations and influencing environmental factors.

The utter dearth of production statistics stands as a serious obstable to the investigation of Indiana lake fisheries. Legal bars against the use of nets and seines and against the sale of game fishes preclude the existence of a commercial fishery. Consequently, the fish production of the lakes with its annual and seasonal variations is largely a matter of surmise. There exist few authentic data upon which to base an estimate.

On the basis of quantitative faunistic studies, we are justified in expecting Indiana lakes to be excelled by none in the production of fishes. Yet there is a constantly increasing cry that "fishing is not what it used to be." Each year more and more people leave the state to fish in lakes which are very probably biologically poorer than our own. In the face of this situation, we are quite without means of determining the degree of the decadence of our fishery, or of judging of its causes; whether it be over fishing, the abundance of predatory enemies, food competitors, or some undetermined and unsuspected factors.

Further, it is unfortunate that, with the exception of one brief paper on the subject (Bolen, 1925), no previous studies of growth rate of fishes in any of the lakes here considered have been made. Had such researches been carried on prior to and during the time of the rapid development of lake resorts with its accompanying increased toll on the fish population, it is highly probable that extremely interesting and instructive results would have been obtained. If increased fishing (and the resultant depletion of the stock) has brought about a change in the growth rate as Strodtman and Langhammer (1925) found in the Baltic plaice, we have no evidence for it.

It is the purpose of this investigation to make an estimate of the growth rate in different lakes for the species studied. The extent of size variation of single age groups from lake to lake and at different times in the same lake will be noted. The increase from one year group to another within the same lake will be indicated. The relationship between weight and length in different collections is determined with a view towards ascertaining the condition of the different groups of specimens. The possible role of food as a factor determining growth and condition will be briefly considered.

ACKNOWLEDGMENTS

I wish to acknowledge my great indebtedness to Dr. Will Scott, Professor of Zoology at Indiana University and Director of the Biological Station, for his valuable advice and supervision during the execution of this work. I am further indebted to Dr. Scott for the scale photographs appearing in this paper.

The Division of Fish and Game of the Department of Conservation, State of Indiana, rendered possible the collection of the data by financing the field work and by furnishing permits for the use of seines and nets.

I wish to thank the persons who, at different times, assisted me in the work of collecting. Mr. John Fleming of the Wawasee Hatcheries aided greatly in the collecting of material in that region. During the summer of 1929, various students from the Biological Station worked with me on collecting trips.

The manuscript has been read and criticized by Dr. Scott and other members of the department.

MATERIAL

The present study is based upon material collected from twenty lakes in Kosciusko and Noble Counties. These lakes are distributed in three drainage areas[1] as follows:

Elkhart Drainage Area
- Lake: Syracuse
  - Wawasee (Turkey)
  - Papakeechie
  - Indian Village
  - Duley
  - Rider
  - Gordy
  - Hyndman
  - Dewart

Tippecanoe Drainage Area
- Lake: Spear
  - Ridinger
  - Dan Kuhn (East)
  - Big Barbee (Hammon)
  - Little Barbee
  - Tippecanoe
  - Little Chapman (Little Eagle)
  - Pike
  - Little Pike
  - Center
  - Winona (Eagle)

Eel Drainage Area
- Lake: Silver

The total number of specimens studied was 1,955.

[1] Hydrographic maps of Dan Kuhn, Chapman, Big Barbee, Ridinger, and Silver Lakes are available in a report by Scott (1916). Maps of Indian Village, Duley, and Gordy Lakes are soon to be published by Dr. Will Scott. Maps of Wawasee and Tippecanoe have been made by the Indiana Department of Conservation.

The following species are represented in the collections:

Family Centrarchidae

Blue Gill	Helioperca incisor (Cuvier and Valenciennes)
Black Crappie	Pomoxis sparoides (Lacépède)
Rock Bass	Ambloplites rupestris (Rafinesque)
Small Mouth Black Bass	Micropterus dolomieu (Lacépède)
Large Mouth Black Bass	Aplites salmoides (Lacépède)
Longeared Sunfish	Xenotis megalotis (Rafinesque)

Family Percidae

Ringed Perch	Perca flavescens (Mitchill)

Family Coregonidae

Cisco	Leucichthys artedi (Le Sueur)

Family Esocidae

Pickerel	Esox lucius L.

Family Moronidae

Silver Bass	Lepibema chrysops (Rafinesque)

The material for this study was, for the most part, collected during the summers 1926 to 1929. Small collections of perch from Lake Wawasee and of blue gills and cisco from Gordy and Indian Village Lakes were made in the late autumn and early winter of 1928. Collection of blue gills and crappies from Indian Village and Duley Lakes, and of a few bass from Wawasee were made in the latter part of April, 1929. In the first three of the summers mentioned, the collections were somewhat incidental to quantitative bottom fauna researches then in progress at Lakes Wawasee and Tippecanoe. The entire summer of 1929 was spent collecting examples from the older year classes in different lakes.

Various methods were employed in securing samples. Many specimens were kindly furnished by fishermen who had taken them by rod and line. Most of the younger year groups (perch, blue gills, black bass, and rock bass) were taken by a 30 foot small meshed seine. All the ciscoes and the older year groups of the other species collected in 1929 were taken by a gill net of 1⅝ inches mesh. Selection, especially by the gill net and to a lesser degree by seine and by hook and line doubtless took place.

In the case of specimens taken by hook and line, difficulty in taking the hook is certainly a selective factor among the smaller fish.

Larger fish escape a seine more readily than do smaller. This factor is neglible, particularly due to the great degree of uniformity of size in the early year classes combined with the great scarcity of older fish in seine catches. Variation of distribution as to depth, correlated with the size of the fish, is probably a greater factor for selection. It is a matter of common observation that fishes tend to distribute themselves from the shallow littoral region to the deeper waters according to the size of the individual. A seine operating in shallow water only could easily miss the larger specimens of a year class. Here the uniformity of size within the first few year groups tends to minimize selection.

The specimens were weighed and measured, and scale samples taken, within a few minutes or at most within a few hours after capture. Length was measured with wooden calipers from the tip of the snout to the edge of the last scales. Readings were made to the nearest one-sixteenth of an inch, and later converted to the nearest millimeter. Weights were taken with Cenco spring balances of 250 and 2,000 grams capacity. The former were graduated in divisions of 10 grams and estimated to the nearest gram; the latter were graduated in divisions of twenty-five grams and estimated to the nearest five grams. A few of the larger specimens (pike, bass) were weighed to the nearest ounce on grocery scales.

Scale samples were taken from the anterior region near the lateral line. They were stored in small envelopes on which were recorded at the same time the details of name, length, weight, and place and time of capture .

Table LXXXI gives the details of numbers of each species collected in the different lakes.

In securing the material for this growth study, it was necessary to effect a three-way compromise based on desire, expediency, and availability, with the latter factor usually dominant. The wish to secure data from as many representative lakes as possible prevented the taking of large samples from any one lake. In several lakes, the results of fishing proved so meager that any attempt at securing a satisfactory sample would be impractical because of the great amount of time required. The gill net used in the summer of 1929 was 160 yards long and had a depth of 12 feet. Yet quite frequently a set of five or six hours netted a catch of less than twenty specimens. As an illustration of the scantiness of the catches, it may be cited that Pike Lake was visited four days, Spear Lake three days, Big Barbee, Little Barbee, and Silver Lakes two days, and Kuhn Lake one day with the results as indicated in the table. The smallness of the catches seems significant in view of the general complaints concerning the decline of fishing and the depletion of the stock.

With the younger year groups, it was usually sufficient to study the scales dry under the microscope. The scales of the older fish were soaked in water, cleaned by rubbing between the folds of a rough linen towel, scrubbed with a small tooth brush, and returned to a watch crystal of water for examination.

THE DETERMINATION OF AGE

The determination of age depends upon the interpretation of structures appearing in the superficial sculpturing of the scale. The annulus or year mark is in the nature of a line of discontinuity dividing two fields of growth. Towards the close of the summer the fish experiences a retardation of growth. During the cold months growth must be very slow, and observations of several investigators indicate that in many instances, at least, it ceases entirely. With the resumption of rapid growth in the spring, the sculpturing of the new area of the scale is laid down with no particular reference to that of the old. A distinct line of demarcation between the two fields results. The annulus does not become definitely apparent until new growth has appeared. If scales be examined from fish taken in the winter or early spring, there will be observed about the periphery the broad band of growth of the preceding season, but no year mark is to be seen.

Several characteristic structures aid in the detection and recognition of the annulus. The first circuli of the new growth of the spring tend to be complete in the postero-lateral region of the scale, whereas the later circuli of the preceding season end at the edge of the scale in this same region. The new lines of growth here meet the older at an angle, producing "cutting over." The degree of prominence of this feature depends largely upon the form of the scale, and becomes less noticeable where there is slight imbrication and the scale retains a rounded form. The annulus is further characterized by the tendency of the circuli to be faint, distorted, and fragmented. A third aid in the detection of the annulus depends on the approximation of the circuli which accompanies the slowing down of growth. The degree of approximation of the circuli is quite variable. In some instances it is hardly noticeable, while in others it may be so great as to cause the appearance of distinct dark bands. These bands are more prominent in the later than in the earlier years of life. Such dark bands are not to be considered as infallible indicators of annuli, for they are of common appearance within summer growth areas. In general, age readings are independent of the shading of the scale. In the region of the ctenii may be observed distinct successive belts, resulting from the different amounts of time the ctenii of succeeding growth zones have been subjected to wear.

Scales are often lost accidentally and regenerated. These regenerated scales have a characteristic appearance which makes them easily identified. The replaced portion is thinner than the original scale, and lacks its typical sculpturing. The center consists of a large plate with no circuli. Towards the outer part of the regenerated portion appear circuli irregularly and widely spaced. Growth occurring beyond the regenerated portion is normal. Such scales are obviously worthless for age determination.

Occasionally scales are loosened and displaced in the pocket, but not lost. In further growth the normal form and position of the scale are reestablished, and the displaced portion appears in the role of an abnormal center.

Frequently injuries involve the destruction of only a part of the scale. Such injuries are repaired, but they disturb the regular sculpturing of the scale.

By comparing partially or wholly regenerated scales with normal scales taken from the same individual, it is possible to determine at what period in the fish's life a particular injury occurred.

The chief difficulties in the use of scales for age determination center about the matter of false rings or accessory annuli. These checks appearing within the growth areas would, if interpreted as true annuli, lead to erroneous age determinations. They may usually be detected by their peculiar appearance or by their position with respect to the true annuli. Some false rings appear consistently in all scales and seem to be the result of conditions effecting the entire fish. Others lack such general distribution and seem to result from irregularities of growth within individual scales.

In many instances accessory growth checks are detectable by being less definite than the true year mark. Cutting over is less pronounced, and the degree of definiteness varies in different parts of the scale, the check being quite prominent in some regions and almost indistinguishable in others. The examination of a considerable number of scales is helpful in determining the validity of a questionable year mark. It is a matter of importance that

scales bearing accessory annuli often present a characteristic confused appearance which puts the investigator on his guard. In a small percentage of cases the sculpturing of the scale may be so confused as to render the scale quite useless for age determination.

Prior to Hoffbauer's (1898) paper lepidologists had confined their attention to the study of the intimate structure and development of scales.[1] Although the use of scales for age determination had been suggested, nothing of a definite nature had been accomplished in that direction. A method of ready age determination filled a deeply felt need of many fisheries investigators. Consequently it became at once the subject of investigation for many workers. A detailed and critical analysis of its basic assumptions followed. Its validity was tested and checked from different angles. Today the literature on the subject is voluminous.

It lies neither within the scope nor the purpose of this paper to enter into an extensive historical and critical survey of the literature on fish scales. Such reviews have appeared from time to time, and are easily avilable.[2] For the purpose of this investigation it is assumed that the validity of the annulus as a true year mark has been sufficiently well established. With the problems pertaining to the use of scales for the calculation of growth, the present study is not concerned.

FOOD AND GROWTH

The task of correlating growth with food conditions is one beset with difficulties. Waiving such factors as chemical condition, average water temperature, the presence of races, etc., let us outline briefly the data concerning which we need information in order to proceed towards a solution:

(1) Available food supply.
(2) Food habits of species considered.
  (a) Variation with increased size.
  (b) Seasonal variation.
  (c) Amount of food selection and degree of flexibility of diet.
(3) Density of population.
(4) Competitors for food.

1. *Available Food Supply.*

The accumulation of data on the amount of food available is a slow and laborious process. Studies must be made concerning both bottom and plankton forms. The values of estimates are greatly enhanced if they are so distributed as to give ideas of the seasonal variation and the variation from year to year. In addition to an estimate of the "standing crop" or food present at a given time, it is well to have some notion of the "turnover" or actual consumption of food. The importance of the problem of production has led to the recognition of the special field of production biology. Calculations of production must be based on a knowledge of standing crops at

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[1] Baudelot (1873) in addition to his own observations on the structure and development of the scales gives an historical review of the work done up to that date. Thomson (1904) also gives a review of the nineteenth century literature bearing on the subject.

[2] For historical summaries and discussion of the scale method, consult Dahl (1909), Taylor (1914), Lee (1920), Creaser (1926), and Van Oosten (1928). Special bibliographies on the subject have been published by Hutton (1921) and Mohr (1927). Graham (1928) gives a survey of the literature which includes abstracts of about seventy papers.

successive periods of time and of the life histories (reproduction, growth rate) of the food forms considered.

The investigators, Peterson, Jensen, Blegvad, and others working from the Danish Biological Station, have studied the problem of production in considerable detail. Their estimates based both on calculation and direct experimentation indicate that the actual production of an area during a given year may at times be greatly in excess of the standing crop at any particular time. Considerable variation from year to year was also noted. It is to be noted further that the absolute density of population may be of importance, for a fish forced to glean a living from a sparsely populated area would be handicapped even in the absence of competitors.

2. *Food Habits of Species Considered.*

(a) That the feeding habits of fishes must change with continued growth is too obvious to require discussion. With increasing size the individual becomes capable of seizing and devouring larger and larger prey, while the forms which formerly constituted his staple articles of diet become too insignificant to warrant the exertion and attention required for their capture. If there is present an adequate supply of all types of food, no inconvenience will result from the change of habit. If, on the other hand the region inhabited is plentifully supplied with food adapted to small fish, but poorly supplied with food for adults, or vice versa, and if migration to more desirable feeding grounds is not feasible by reason of distance or natural barrier, the nature of growth is likely to be affected correspondingly. Borley (1912), in his studies of the condition of plaice in the North Sea, detects regions which are favorable for the growth of the young, but not of the adult. He explains the better growth of plaice on the Dogger Bank on the basis of the excellent supply of food for *adults* there present.

(b) The problem of seasonal variations in feeding habits is connected with food forms having a brief life history. Different food forms show great variation as to numbers at different times of the year. There are definite times of scarcity and abundance. A particular region may at one season be a very rich feeding ground, and at another much less favorable. There may also be a seasonal variation in diet brought about through voluntary selection on the part of the fish. Todd (1915) finds the plaice feeding predominantly on Polychaets in the winter and on Mollusca in the summer. He suggests that the crowded condition of the viscera due to the swelling of the sexual organs might cause particles of shells to be a source of "considerable danger or discomfort." Hardy (1924) suggests that the marked seasonal changes of diet in the herring and mackerel may be due to the need of nourishment for the ripening gonads.

(c) To say that a given form is an element of the food of a certain fish may imply that the fish consumes this form by predilection or through force of necessity. In the presence of a great abundance and variety of food, a fish may well afford to exercise choice and select that which seems most suitable. But what is the condition in the case of a scanty or monotonous food supply? Will the species concerned fail to inhabit such a locality altogether, or will it adapt itself to the adverse conditions of living?

Hertling (1928), in a detailed study of the stomach contents of the plaice, dab, and flounder, correlated with bottom fauna data, found a distinct variation in the food of the three species, correlated definitely with structure

and habit. Such were the conditions where a considerable variety of food was present. Yet in the Gotlandmulde inhabited by an animal community devoid of molluscs (Tiefengemeinschaft), the flat fishes seemed to have been able to accommodate themselves to a diet consisting exclusively of annelids and crustaceans.

Jensen (1919), in a similar investigation, concludes that "it is mainly the same species, which are found in stomach content and in bottom." There was, however, some degree of selection noticed.

3. *Amount of Food per Individual.*

It is not so important to know the actual amount of food present as the actual amount per individual. The amount of food per individual is a factor mutually interactive with the density of population. A region which might naturally constitute an excellent feeding ground may be held in a statement of impoverishment by a too dense population. Further, the value per individual of any definite amount of food is dependent upon the number of feeders.

Precise and definite data as to density of fish population are, of course, difficult to obtain. It is an easier task to relegate comparable areas to such categories as very dense, dense, . . . to very sparse. Such a classification, while certainly lacking in mathematical definiteness, suffices in most instances for purposes of comparison. Data concerning the relative abundance of fishes are mostly obtained through experimental catches and from fisheries statistics.

There are numerous instances cited in the literature of the relationship between density of population and growth rate.

It was early observed by Danish fishermen in the Limfjord that plaice were plentiful but undersized in the Thybown Channel and adjacent parts of the North Sea and Nissum Broad, while they were scare but of good growth in the inner broads. On the basis of these observations, it was decided to try the effect of transplantation of the small fish to the inner parts of the Limfjord. The first transplantation was made in the spring and summer of 1892. The good results obtained led to a continuation of the work up to the present time. (Due to war conditions, no fish were transplanted in 1917.)

The increased rate of growth resulting from the transfer to regions having more plentiful food made the experiments quite profitable. Although approximately three-fourths of the fish are retaken within the same calendar year of liberation, the yield amounted to 3.5 tons per ton planted for the years 1901-07. Recent years have showed a tendency for the yield to decrease.

Within recent years the flat fish fishery of the Western Baltic has suffered severe depletion. Strodtmann and Langhammer (1925) have noted that there has been at the same time an increase of growth rate. The better growth they attribute to more favorable food conditions. Hertling's study of stomach contents, correlated with bottom sample statisics, seems to support their contention.

Huitfeldt-Kaas (1927) assigns as chief cause for variation in weight and size in different localities " . . . the varying access to the food on the part of the fish." He regards the "dwarf races" as starvation forms. In an earlier paper by the same author,[1] the relationship between overpopulation

[1] This paper is summarized by Rugde in *The Salmon and Trout Magazine*, No. 34, December, 1923.

and starvation forms is discussed. It is a custom among the Norwegian farmers to "keep the trout under discipline." If the fish in a particular lake begin to appear undersized and emaciated, they proceed to remedy the condition through more intensive fishing. If the trout become scarce, restrictions are laid upon fishing. Such control is simple and, on the whole, quite effective in the regions where the trout is the only species of fish. Where there are numerous species of fish, control becomes quite difficult.

After the trout, which was introduced into New Zealand, became numerous, that country was confronted with a pressing problem of overpopulation. A review of Tillyards' paper on the subject appears in the *Salmon and Trout Magazine*. The trout, finding themselves in an environment rich in natural food, fed voraciously, and increased prolifically. Their growth was rapid, and they attained unusual sizes. The native stock of insect forms was unable to maintain itself against such incursions with the result that there in time came to be a plentiful supply of trout and a very scant amount of food. The trout began to show poor condition, and to be subject to parasites. As a remedy, Dr. Tillyard recommends the relaxation of legal restraints to the taking of trout and the confining of spawning to certain selected streams (to be changed from year to year).

Pirognikoff (1927) describes another instance of the relationship between density of population and rate of growth. By comparing his own data on the growth of the dace (Rutilus rultilus lacustris Pallas) in Lake Chani with earlier data, he has detected a distinct decline in the rate of growth since 1918. The falling off in growth is considered the result of the decline of the fishery. Intensifying of the fishery is suggested as a remedy.

4. *Competitors for Food.*

Where several species live in a state of common competition for food, the matter of relationship between population and food supply becomes quite complex. It is now important to have knowledge of the details of the feeding habits and abundance of several forms. The "degree of competition" should be known, for it is not likely that several species will have identical tastes and feeding habits.

An interesting study of the feeding relationships of different species is given by Blegvad (1927). The cod fisheries of the Limfjord are subject to marked periodic variations. The viviparous blenny, Zoarces, and the gobies upon which the cod feeds voraciously show an abundance approximately in inverse ratio to that of the last named fish. Since Zoarces and the gobies are food competitors of the plaice, it is to be expected that in their periods of abundance the amount of available plaice food will be lowered. Such seems to be the general trend. Blegvad points out that, in the years 1924-27, there has been an increasingly poor catch of cod. At the same time, the number of Zoarces has increased enormously, while the plaice food per unit area of bottom has diminished notably.

AVERAGE LENGTH AND WEIGHTS IN THE VARIOUS COLLECTIONS

In the following sections will be presented the data from the different collections in the various lakes. There will be presented for each species in each collection the number of individuals in each year class with the average values for weight in grams and length in centimeters. This material is given for the

greater part in tabular form. The tables are accompanied by statements of the method of collection and by the discussion of significant points in the data.

The ages, O, I, II, ——— refer to the number of winters through which the fish have lived. Thus, a fish in the summer in which it has been hatched belongs to the O group, for it has passed no winters and shows no annuli. In the second summer after its hatching, it has passed one winter and accordingly belongs to the I group; in its third summer it belongs to the II group; in the fourth to the III group ———. The various groups are designated as the first summer, one year, two years, ——— classes. An explanation of the terminology used is necessary since some workers have used the numbers I, II, III, ——— to designate the numbers of summers passed by the fish. Under this system, for example, a fish in its second summer belongs to the II group.

While the latter system would be the more suitable in the case of such forms as the cisco which is ordinarily taken at the close of a growing season, the method of designating age by the number of winters is employed throughout this paper as being more descriptive for the material at hand, for few of the specimens studied here were taken either near the beginning or the end of a growing season.

SYRACUSE

Collections were made July 3, 1926, and July 7 and 8, 1927. The 1926 collection, which was furnished by fishermen at the lake, consisted of 22 blue gills and 2 perch. The 1927 collection was taken by a small mesh 30 foot seine. It contained 19 perch, 15 large mouth black bass, 13 rock bass, 10 longeared sunfish, and 7 blue gills—all belonging to the early year groups.

Two III group perch taken in 1926 had an average weight of 79 grams, and an average length of 14.7 cm.

TABLE I.
Syracuse Blue Gills 7/3/1926

Age	Number	Weight	Length
II	19	64	11.2
III	1	180	17.3
IV	1	173	17.1
V	1	210	17.6

TABLE II.
Syracuse Perch 7/7 and 8/1927

Age	Number	Weight	Length
0	3	..	4.2
I	12	12	9.6
II	4	21	11.1

TABLE III.
Syracuse Large Mouth Black Bass

Age	Number	Weight	Length
0	1	.	3.7
I	13	14	9.5
II	1	55	14.0

TABLE IV.
Syracuse Rock Bass

Age	Number	Weight	Length
I	4	6	5.9
II	8	33	10.0
III	1	72	12.9

TABLE V.
Syracuse Longeared Sunfish

Age	Number	Weight	Length
I	1	8	6.4
II	6	26	9.2
III	1	35	10.0
IV	1	50	11.1
V	1	63	12.4

TABLE VI.
Syracuse Blue Gill

Age	Number	Weight	Length
I	3	.	5.1
II	4	25	9.7

WAWASEE (TURKEY LAKE)

Collections were taken from Wawasee each year from 1926 to 1929. The totals include 635 yellow perch, 157 blue gills, 56 rock bass, 53 large mouth black bass, 13 black crappies, 10 small mouth bass, 5 pickerel, and 3 longeared sunfish—in all, 932 specimens.

YELLOW PERCH

The perch from the 1926 collections were furnished by fishermen, and were taken by hook and line. Table VII summarizes the data on these specimens. Since the times of catching were scattered through the latter part of July and the early part of August, all collections are considered together.

TABLE VII.

Wawasee Yellow Perch—1926

Age	Number of Specimens	Average Length	Increase	Per Cent Increase	Average Weight	Increase	Per Cent Increase
I	5	9.4	....	...	10.8	... .	....
II	25	13.7	4.3	46	43.6	32.8	304
III	27	16.6	2.9	21	75.6	32.0	73
IV	9	19.3	2.7	16	137.3	61.7	82
V	3	22.0	2.7	14	179.7	42.4	31

TABLE VIII.

Wawasee Yellow Perch—1927

Age	Number of Specimens	Average Length	Increase	Per Cent Increase	Average Weight	Increase	Per Cent Increase
0	9	3.4	....	....	....	.... ..	.... .
I	216	8.8	5.4	162	10.5	... ..	... .
II	70	13.5	4.8	54	41.9	31.4	299
III	2	16.8	3.2	24	94.5	52.6	125

The data indicate the greatest increase in length in the first three years of life. The weight increase mounts consistently, reaching a maximum from the third to the fourth year. Growing with respect to both length and weight appears to be slowing down from the fourth to the fifth year. Attention should be given to the column showing percentages of increase. Each percentage tabulated is a comparison between the increase for the year and the weight or length for the preceding year. The greatest actual increase and the greatest percentage increase in length occur from the first to the second year.

The averages for 1927, Table VIII, compare well with those of 1926. The differences are no greater than might be expected to result from smallness of samples, differences in time and method of collection, and from experimental error in measurement.

All but three of the perch collected in 1927 were taken by seine at the south end of Morrison's Island. The dates of collection were July 7, 14, 28. The samples were sufficiently large that they should show an increase in size

between the succeeding times of collecting. Such increase is clearly indicated in the data of the following tables.

TABLE IX.
Wawasee One Year Perch—1927

Date of Collection	Number of Specimens	Length	Increase
7- 7-1927	27	8.31	....
7-14-1927	153	8.78	.47
7-28-1927	36	9.16	.38

TABLE X.
Wawasee Two Year Perch—1927

Date of Collection	Number of Specimens	Length	Increase
7- 7-1927	11	12.99	....
7-14-1927	38	13.44	.45
7-28-1928	18	13.84	.40

Collections were made in 1928 on June 19, 20, 28, and 30, August 14, and November 10 and 11. The last of these collections was made by means of a gill net at the south-eastern extremity of the lake. The others were made by seine at the southern end of Morrison's Island, and are strictly comparable to the collections of 1927.

TABLE XI.
Wawasee Perch—1928

Age	Number of Specimens	Average Length	Increase	Per Cent Increase	Average Weight	Increase	Per Cent Increase
0	10	4.4	....	....	....	......	....
I	77	8.1	3.7	84	8	......	....
II	106	12.0	3.9	48	28	20	250
III	3	16.8	4.8	40	75	47	168
IV	4	20.3	3.5	21	147	72	96

TABLE XII.
Wawasee One Year Perch—1928

Date of Collection	Number of Specimens	Length	Increase
6-19, 20	21	7.5	....
6-28	5	7.7	.3
6-30	25	7.9	.2
8-14	26	9.0	1.1

TABLE XIII.
Wawasee Two Year Perch—1928

Date of Collection	Number of Specimens	Length	crease
6-19, 20	18	11.7	....
6-28	14	12.1	.4
6-30	74	12.0	—.1
10-10, 11	7	16.4	....

The total length increase indicated from June 19 to August 14 is 1.6 centimeters.

The growth from June 19 to June 30 was between .3 and .4 centimeters. The large average for the November sample was probably the result of selection by the gill net.

A single collection was made in 1929 on July 1.

TABLE XIV.
Wawasee Perch—7/1/29

Age	Number	Weight	Length
I	38	7.1	8.1
II	18	32	13.5
III	1	52	16.4

The length increase from the I class to the II class was 4.4; the weight increase 25 grams.

For a summary of all perch collections on Wawasee consult Table LXXVIII. It will be seen that on the whole there is good agreement between the averages for the different years, particularly in the early year groups.

BLUE GILLS

During July and August, 1926, measurements and scale samples were taken from 111 blue gills furnished by fishermen at the lake. Collections of later seasons were small and scattered.

TABLE XV.
Wawasee Blue Gills—1926

Age	Number of Specimens	Length	Increase	Per Cent Increase	Weight	Increase	Per Cent Increase
II	77	11.4	..	. .	49	. . . . . .	. . .
III	18	15.5	4.1	36	132	83	169
IV	14	18.4	2.9	19	210	78	60
V	7	19.3	.9	5	246	36	17
VI	1	21.0	1.7	8	325	79	32

The greatest actual and percentual increase in the above collection was from the II to the III class. There were no data on the O and I year classes. The data for later collections follow:

TABLE XVI.
Wawasee Blue Gills—July, 1927

Age	Number	Weight	Length
I	14	. .	5.3
II	7	29	9.8
III	2	250	20.2

TABLE XVII.
Wawasee Blue Gills—6/30/1928

Age	Number	Weight	Length
III	1	123	14.1
IV	2	183	17.2
V	6	244	18.2
VI	1	300	20.3

TABLE XVIII.
Wawasee Blue Gills—April, 1929

Age	Number	Weight	Length
III	4	127	15.6
IV	2	149	16.6
VI	1	275	19.7

TABLE XIX.
Wawasee Blue Gills—6/18 and 7/5/29

Age	Number	Weight	Length
III	2	147	15.4
IV	1	300	19.7
V	1	305	20.0

Year groups I and II of the 1927 collection were taken by seine in the shallow water off the south end of Morrison's Island. The specimens of June 30, 1928, were taken by Mr. John Fleming of the Wawasee Hatcheries on a fly rod. All the 1929 individuals were taken in a 1⅝ inch mesh gill net. The different methods of collecting and the scarcity of material may account for the irregularities apparent.

ROCK BASS

The time of collection for rock bass ranged from July 15 to August 23 for 1926, from June 27 to July 25 for 1927, and from June 18 to July 1 for 1929. The five 1928 specimens were taken by seine June 19 and 20.

TABLE XX.
Wawasee Rock Bass—1926

Age	Number	Weight	Length
II	2	75	13.2
III	3	105	14.2
V	1	174	17.0
VI	1	365	22.7
VII	1	415	23.3

TABLE XXI.
Wawasee Rock Bass—1927

Age	Number	Weight	Length
I	14	55	5.6
II	5	38	10.5
III	5	98	14.5
IV	4	180	17.8
V	2	230	18.4
VII	2	290	23.4

TABLE XXII.
Wawasee Rock Bass—1928

Age	Number	Weight	Length
I	5	. .	5.1
II	1	25	9.7
III	1	110	14.6
IV	4	218	18.6
V	1	275	20.3
VII	1	400	21.9

TABLE XXIII.
Wawasee Rock Bass—1929

Age	Number	Weight	Length
I	1	. .	5.1
III	1	153	17.2
V	1	365	21.8

All members of the I group were taken by seine at the eastern end of the lake. The older classes of the 1926 and 1927 collection were furnished by fishermen. The single III and V specimens of 1929 were taken in a 1⅝ inch mesh gill net.

The above data, meager as they are, make possible an interesting comparison with the results of Wright's (1929) study of the growth of the rock bass in northern Wisconsin. The longest specimen found by Dr. Wright had a length of 18.5 cm. His oldest individuals belonged to the XI year group. In the specimens collected from Wawasee, the maximum length was 23.7 cm., while the oldest year group represented was VII.

LARGE MOUTH BLACK BASS

The bass collected in 1929 were taken by a 1⅝ inch mesh gill net. All specimens of the I and II group were taken by seine. The remainder of the specimens were furnished by fishermen.

In 1926, only two specimens were measured. One was in the V group, having a length of 34 cm. and a weight of 840 grams. The other had passed eight winters and had a length of 38.1 cm. Its weight was 1250 grams.

Fifteen specimens were taken in July, 1927.

TABLE XXIV.
Wawasee Large Mouth Bass—1927

Age	Number	Weight	Length
I	4	26	10.6
III	3	233	22.6
IV	2	375	27.7
V	6	594	30.9

In 1928, eight small specimens were taken by seine. On July 14, 5 individuals belonging to the I group, and having an average length of 8.4 cm. and average weight of 11 gm., were taken. At the same time, a single speci-

men of the II group was taken. It was 16.5 cm. long and weighed 90 grams. In the latter part of June, 2 belonging to the II group were taken. They had an average length of 14.8 cm. and an average weight of 69 grams.

In the latter part of April, 21 bass were collected. Five more were collected on June 18 and July 5.

TABLE XXV.
Wawasee Large Mouth Bass—1929

Date	Age	Number	Weight	Length
April	IV	19	402	26.2
April	V	2	675	29.2
6-18, 25	III	5	357	25.1
6-18, 25	IV	2	423	27.4

TABLE XXVI.
Wawasee Crappies

Date	Age	Number	Weight	Length
7-25-27	IV	1	215	20.6
7- 5-29	III	8	149	18.3
7- 5-29	IV	4	190	19.4

Of the fish taken in April, all but 1 or 2 of the smaller specimens in the IV group would have spawned.

BLACK CRAPPIE

The collections of crappies are given in Table XXVI.

SMALL MOUTH BLACK BASS

Three specimens were measured in July, 1926, and 7 in July, 1927.

TABLE XXVII.
Wawasee Small Mouth Bass

Date	Age	Number	Weight	Length
July, '24	V	1	400	27.3
July, '24	VI	1	820	33.7
July, '24	IX	1	1000	37.8
July, '27	IV	3	420	27.4
July, '27	VI	3	500	31.8
July, '27	VIII	1	1590	41.0

TABLE XXVIII.
Wawasee Pickerel

Date	Age	Number	Weight	Length
7-18-26	III	1	225	30.3
April, '29	IV	1	850	48.3
April, '29	V	2	2350	69.8
April, '29	VI	1	2725	83.7

PICKEREL

Five specimens were taken. See Table XXVIII.

LONGEARED SUNFISH

Three specimens were taken.

TABLE XXIX.
Wawasee Longeared Sunfish

Date	Age	Length
7-14-27	II	7.5
7-14-27	III	11.2
6-28-28	II	7.5

PAPAKEECHIE

Only a few scattered specimens were obtained from Papakeechie. This lake, which is artificial and privately owned, has rather stringent limitations on fishing. It is reputed to contain blue gills of a size smaller than the

average, although plentiful as to number. Bass fishing is good and the fish well grown. A collection of blue gills adequate for age study would, if available, be of interest. The belief is common that the blue gills are too plentiful because of insufficient fishing. A dense population of undersized blue gills would, of course, improve the situation among the bass.

TABLE XXX.
Papakeechie Blue Gills—8/8/1926

Age	Number	Weight	Length
V	2	94	14.7
VI	1	105	15.7

TABLE XXXI.
Papakeechie Perch—8/8/1926

Age	Number	Weight	Length
VI	1	223	23.0

TABLE XXXII.
Papakeechie Black Crappie—8/8/1926

Age	Number	Weight	Length
V	1	255	20.8
VI	1	227	20.3

TABLE XXXIII.
Papakeechie Large Mouth Bass

Date	Age	Number	Weight	Length
8- 8-26	IV	1	210	22.3
7-14-26	VIII	1	1225	37.2
6-16-26	XVI?	1	2120	44.5
4-21-29	VIII	1	1050	37.5

INDIAN VILLAGE LAKES

Collections were made from the lower five lakes of the Indian Village chain. The channels by which the lakes communicate are large enough for passage by boat. Since the shores are in general marshy, none of the five lakes considered has been exploited for resort purposes. Consequently, the fishing is here less intensive than in most lakes. In the past, there has been a decreasing number of fish removed from the lakes by nets.

Collections from the Indian Village and Gordy Lakes were made in the early winter of 1928 at the spawning time of the ciscoe; from Indian Village and Duley Lakes on April 23, 1929; from Rider Lake June 22, 1929; from Gordy Lake July 23, 1929; and from Hyndman Lake August 12 and 13, 1929. The fish taken in 1928 were caught in a 1⅝ inch mesh gill net, and in a trammel net whose smaller mesh was 1⅝ mesh. All fish collected in 1929 were taken in a 1⅝ inch mesh net.

INDIAN VILLAGE

CISCO

Collections of ciscoes were made in the last four days of November, 1928, and July 23, 1929.

TABLE XXXIV.
Indian Village Cisco—November, 1928

Age	Number	Weight	Length
II	1	293	25.7
III	19	469	30.4
IV	15	530	31.9
V	8	613	32.7
VII	1	810	33.3

TABLE XXXV.
Indian Village—7/21/1929

Age	Number	Weight	Length
IV	9	553	32.4
V	7	615	33.4
VI	2	635	33.4

It should be noted that while the various groups have passed II, III, . . . winters, they have completed 3, 4, . . . growing seasons. The weight data for the 1928 collection are somewhat unreliable because of the admixture of both spawned and unspawned individuals.

BLUE GILLS

In 1929, 34 blue gills were collected April 23, and 14 on July 21.

TABLE XXXVI.
Indian Village Blue Gills—4/23/1929

Age	Number	Weight	Length
III	3	130	15.9
IV	28	150	16.6
V	3	186	18 4

TABLE XXXVII.
Indian Village Blue Gills—7/21/1929

Age	Number	Weight	Length
III	9	139	16.4
IV	3	182	18.0
V	1	200	18.1

CRAPPIES

Twelve crappies were collected on April 4, and 3 on July 21, 1929.

TABLE XXXVIII.
Indian Village Crappies—4/4/1929

Age	Number	Weight	Length
IV	8	168	18.5
V	3	220	20.6
VI	1	232	20.8

TABLE XXXIX.
Indian Village Crappies—7/21/1929

Age	Number	Weight	Length
III	3	150	18.3

LARGE MOUTH BLACK BASS

A single large mouth bass (4/23/29) of the IV group was 24.1 cm. long and weighed 320 grams.

DULEY

An April 23, 1929, a catch of 8 crappies and 53 blue gills was made. A 1⅝ inch mesh gill net was used.

TABLE XL.
Duley Blue Gills—4/23/29

Age	Number	Weight	Length
III	2	131	15.8
IV	42	138	16.3
V	5	155	16.9
VI	3	178	17.6
VII	1	220	19.1

Eight crappies of the III group had an average length of 18.0 cm., and an average weight of 140 grams.

RIDER

On July 20, 1929, a catch was made of 24 blue gills, 6 crappies, and 2 large mouth bass.

TABLE XLI.
Rider Blue Gills—7/20/29

Age	Number	Weight	Length
III	15	127	15.8
IV	7	158	16.9
V	2	205	18.7

The crappies belonged to the III group. Their average weight was 156 grams and their average length 18.8 cm. The two bass belonged to the V group. They had an average weight of 5.5 gm., and an average length of 27.4 cm.

GORDY

From November 26 to December 1, 1928, 13 cisco and 9 blue gills were taken. On July 23, 1929, a catch of 11 cisco and 25 blue gills was made. In the 1928 collection, a gill net and a trammel net with a 1⅝ inch smaller mesh were used. In 1929, the gill net alone was employed.

TABLE XLII.
Gordy Cisco—11/26 to 12/1/29

Age	Number	Weight	Length
II	1	265	26.4
III	12	452	29.6

TABLE XLIII.
Gordy Cisco 7/23/29

Age	Number	Weight	Length
IV	4	538	31.8
V	5	751	37.7
VI	2	940	39.4

TABLE XLIV.
Gordy Blue Gills—11/26/28

Age	Number	Weight	Length
III	4	127	15.6
IV	2	149	16.6
VI	1	275	19.7

TABLE XLV.
Gordy Blue Gills—7/23/29

Age	Number	Weight	Length
III	9	126	15.9
VI	14	166	17.5
V	2	199	18.7

HYNDMAN

Collections made August 12 and 13, 1929, included 46 blue gills and 11 ciscoes. A gill net was used.

TABLE XLVI.
Hyndman Blue Gills—8/12, 13/29

Age	Number	Weight	Length
III	33	136	16.5
IV	11	162	17.1
V	2	226	19.3

TABLE XLVII.
Hyndman Cisco—8/12, 13/29

Age	Number	Weight	Length
II	1	275	26.0
III	3	455	29.4
IV	5	434	29.0
VI	2	770	33.8

DEWART

Collections were made by means of gill nets, August 21 and 22, 1929. The collection included 45 blue gills, 7 crappies, 6 perch, and 1 large mouth black bass.

TABLE XLVIII.
Dewart Blue Gills—8/21, 22/29

Age	Number	Weight	Length
III	35	130	16.0
IV	9	160	17.7

One of the IV group specimens was not included in the computation of the averages. It had sustained an injury in which a considerable portion of the upper and lower jaw had been torn away on the left side. The wound was thoroughly healed, and the fish was in good condition. It was, however, somewhat undersized, having a weight of 112 gms. and a length of 15.9 cm. It was a female. The scales showed normal sculpturing.

Separate averages were computed for the 20 females and the 15 males of the III group.

TABLE XLIX.
Dewart, III Group—Blue Gills

Sex	Number	Weight	Length
♀	20	132	16.2
♂	15	128	15.8

The females show a slightly larger average for both weight and length.

CRAPPIES

The seven crappies all belonged to the III group. The average weight was 166 gms.; the average length 18.6 cm.

PERCH

The six perch, all members of the IV group, had an average weight of 355 gms. and an average length of 26.4 cm. All six were females. Dewart Lake is reputed for its perch, and these well grown specimens indicate the reputation to be well grounded.

LARGE MOUTH BASS

A single large mouth bass belonging to the IV group weighed 435 gms. and was 27.6 cm. long. The specimen was a female.

SPEAR

Attempts to secure data from Spear Lake proved singularly unfruitful. Below are the results from the three times the Lake was fished.

TABLE L.
Spear Lake—1929

	Age	Number	Weight	Length	Date
Large Mouth Bass...	V	1	400	27.0	4-18-29
Large Mouth Bass......................	VII	1	660	31.4	4-18-29
Large Mouth Bass...	IV	1	325	26.0	6-27-29
Blue Gill.......	III	1	150	17.0	7- 5-29
Crappie................................	III	2	167	19.4	7- 5-29

RIDINGER

An attempt at making a collection at Ridinger Lake June 20, 1929, netted only 3 blue gills and 3 crappies. All the specimens belonged to the III group.

TABLE LI.
Ridinger—6/20/29

	Weight	Length
Blue Gills	121	16.6
Crappies	166	19.0

BARBEE CHAIN

Of this chain of six lakes, Little Barbee, Big Barbee (Hammon), and Dan Kuhn (East) were fished for specimens. The results of the fishing in Dan Kuhn were negligible. A gill net was used in all collections.

The communicating channels are sufficiently large to be negotiated by row boats at all seasons.

BIG BARBEE (HAMMON)

The collections of July 15 and 29, 1929, consisted of 20 blue gills and 9 crappies.

TABLE LII.
Big Barbee Blue Gills—1929

Age	Number	Weight	Length
III	16	129	15.8
IV	4	175	17.8

TABLE LIII.
Big Barbee Crappies—1929

Age	Number	Weight	Length
III	6	145	18.4
IV	3	169	19.3

LITTLE BARBEE

Collections were made July 13 and 30, 1929. Fourteen blue gills and 6 crappies were taken. Gill nets were used.

TABLE LIV.
Little Barbee Blue Gills—1929

Age	Number	Weight	Length
III	13	119	15.6
IV	1	170	17.6

TABLE LV.
Little Barbee Crappies—1929

Age	Number	Weight	Length
III	2	131	17.7
IV	3	144	18.6
V	1	197	20.0

DAN KUHN (EAST) LAKE

An attempt to make a collection on July 31, 1929, resulted in the capture of only four blue gills.

TABLE LVI.
Dan Kuhn Blue Gills—1929

Age	Number	Weight	Length
III	2	128	16.6
IV	2	145	17.6

LITTLE CHAPMAN (LITTLE EAGLE)[1]

Twenty-five blue gills were taken from Little Chapman Lake July 6, 1929. A gill net was used.

TABLE LVII.
Little Chapman Blue Gills—7/6/29

Age	Number	Weight	Length
III	12	124	15.9
IV	13	152	16.9

The presence of such a large percentage of the IV group suggests the possibility that many of the III group were small enough to escape the net.

CENTER

Eighteen blue gills and one crappie were taken from the Center Lake July 2, 1929. The collection was made by means of a gill net.

TABLE LVIII.
Center Blue Gills—7/2/27

Age	Number	Weight	Length
III	15	126	15.6
IV	3	148	16.5

The crappie was from the III group. Its weight was 173 gms., and its length 18.7 cm.

PIKE

Although this lake was visited on several occasions, the total collection was quite small. Pike Lake seems to be infested with a considerable number of dogfish, gar-pike, carp, and suckers. The collections of July 8, July 10,

[1] The name Little Eagle properly includes two lakes, Big Chapman and Little Chapman. Draining projects have lowered the level of Little Eagle, dividing it into two smaller and definitely separated bodies.

and August 6, 1929, contained 5 blue gills, 5 crappies, 2 pickerel, and 1 silver bass.

TABLE LIX.
Pike—1929

Name	Age	Number	Weight	Length
Blue Gill	III	5	125	15.9
Crappie	III	5	160	19.8
Pike	IV	2	1190	53.5
Silver Bass	III	1	365	25.1

LITTLE PIKE

Little Pike is a small lake communicating with Pike Lake by a channel, easily navigable in a row boat. The shore line is mostly marshy, and the vegetation abundant in the littoral region. As is the case with Pike Lake, Little Pike seems to have a considerable population of carp and suckers. The lake is highly reputed for pickerel fishing.

Collections were made July 10 and August 6, 1929. The two collections contained 12 crappies, 9 blue gills, 4 pickerel, 3 silver bass, and 1 large mouth bass. Since the number of specimens is so small, the two samples have been combined in the presentation of data.

TABLE LX.
Little Pike Crappies—1929

Age	Number	Weight	Length
IV	6	165	19.6
V	4	215	22.3
VI	2	320	24.2

The crappies from Little Pike are of a larger size than those found in the collections from most lakes.

TABLE LXI.
Little Pike Blue Gills—1929

Age	Number	Weight	Length
III	6	119	15.2
IV	3	131	16.1

TABLE LXII.
Little Pike Pickerel—1929

Age	Number	Weight	Length
IV	1	825	45.7
V	2	795	45.0
VI	1	1375	45.6

Three silver bass of the III group had an average weight of 560 gm. and an average length of 28.6 cm.

A large mouth bass weighing 425 gm. and 26.4 cm. long belonged to the IV group.

WINONA (EAGLE)

Samples from Winona before 1929 were small and scattered. In 1929, a total of 129 blue gills and 54 crappies were collected. Most of the specimens of the year group III and above were taken by means of a gill net. The smaller ones were taken by hook and line.

BLUE GILLS

Only four blue gills were obtained before 1929. Table LXIII.

TABLE LXIII.
Winona Blue Gills—1925-26

Date	Age	Number	Weight	Length
8-19-25	II	1	28.2	11.0
7-31-26	I	1	12.5	8.0
7-24-26	II	2	.	11.9

TABLE LXIV.
Winona Blue Gills, I Group—1929

Date	Number	Weight	Length
7-14	7	12	8.1
8-1	2	18.5	9.1

Nine I group specimens were taken in 1929. Table LXIV.

The size of these specimens is perhaps too great, since they were taken by hook and line.

A total of 80 specimens in the II group were taken in four collections.

TABLE LXV.
Winona Blue Gills, II Group—1929

Date	Number	Weight	Length
6-29-29[1]	21	...	11.5
7-13-29	15	43	11.7
8- 1-29	41	42	11.6
8- 8-29	3	42	11.8

The data do not indicate a very rapid growth in July and early August. Such growth may be obscured by selective sampling.

The 23 blue gills of the III group have been divided into two groups, one collected during the month of July and the other during the first nine days of August.

TABLE LXVI.
Winona Blue Gills, III Group—1929

Month	Number	Weight	Length
July	10	115	15.0
August	13	108	15.1

TABLE LXVII.
Winona Blue Gills, IV-V Groups—1929

Age	Number	Weight	Length
IV	16	138	16.9
V	1	183	19.1

CRAPPIES

A single crappie was taken August 19, 1925. It belonged to the II group and had a weight of 82 gms. and a length of 15.6 cm.

Only one II group specimen was taken in 1929 (July 19). It weighed 75 gms. and was 14.9 cm. long.

Eleven III group crappies were taken in July and 14 during the first nine days of August.

TABLE LXVIII.
Winona Crappies, III Group—1929

Month	Number	Weight	Length
July	11	141	18.2
August	14	151	18.4

[1] These scales and measurements for specimens were furnished by Miss Ulrey. Weights were given to the nearest half ounce.

In the IV group, 16 were collected in July 15 in early August.

TABLE LXIX.
Winona Crappies, IV Group—1929

Month	Number	Weight	Length
July	10	228	21.1
August	15	246	21.2

TABLE LXX.
Winona Crappies, V Group—1929

Month	Number	Weight	Length
August	3	303	22.8

PERCH

Thirty-three perch were collected by means of a seine August 14 and 19, 1925.

TABLE LXXI.
Winona Perch—August, 1925

Age	Number	Weight	Length
0	15	1.9	5.2
I	10	9.8	8.6
II	8	27.3	12.2

The average weights are given to the nearest tenth of a gram. These specimens were weighed on beam arm balances at the Biological Station. Although it is possible that some of the smaller perch of the O group escaped through the meshes of the seine, it is still evident that the perch enjoys a good growth in its first season. The weight of the O fish is less than might be expected in fish of their length.

LONGEARED SUNFISH

Two collections of longeared sunfish were made. In 1927, 17 specimens were taken on June 22 and 27. In 1929, 8 were taken on July 14. The 1927 fish were taken by a seine; the 1929 fish by hook and line.

TABLE LXXII.
Winona Long Eared Sunfish—1927

Age	Number	Weight	Length
II	9	16	7.3
III	4	28	8.1
IV	2	33	9.2
V	2	34	9.4

TABLE LXXIII.
Winona Long Eared Sunfish—1929

Age	Number	Weight	Length
II	5	13	7.7
III	3	41	11.2

LARGE MOUTH BASS

Dr. Scott furnished data from 5 large mouth black bass caught by him.

TABLE LXXIV.
Winona Large Mouth Bass

Date	Age	Weight	Length
7- 4-26	IV	486	32.4
7- 4-27	VII	1746	40.6
7-20-27	V	650	33.0
8-17-27	VIII	1250	40.6
7- 4-27	V	1025	40.3

ROCK BASS

Only one rock bass was obtained from Winona. This specimen, taken July 31, 1926, weighed 187 gm. and was 17.1 cm. long. It belonged to the year group V.

SILVER LAKE

Silver Lake was fished with a net August 10 and 17, 1929. Fifteen blue gills and 2 crappies were collected.

TABLE LXXV.
Silver Blue Gills—1927

Age	Number	Weight	Length
III	14	135	16.5
IV	1	163	18.3

The 2 crappies belonged to the III group. They had an average weight of 136 gm. and an average length of 17.6 cm.

RELATIONSHIP BETWEEN WEIGHT AND LENGTH

It has been found that within reasonable limits of variation, the weight of a fish varies directly as the cube of its length; i. e.:

$$\frac{W}{L^3} = c, \qquad \text{or}$$

$$W = cL^3 \qquad \text{where c is a constant.}$$

Where W is expressed in grams and L in centimeters, it is found convenient to introduce another constant K where

$$\frac{K}{100} = c.$$

The equation then becomes

$$W = \frac{KL^3}{100}.$$

The value of the constant K is in general characteristic for a given species. Its variations may then be taken as indicative of variations in condition of the different individual fishes. Because of its significance in indicating the condition of fishes, K has come to be termed the "coefficient of condition."

The chief factors producing variations in the value of "K" are sexual state and feeding conditions. Where there is no distorition of the relation-

ship from sexual development, K may be taken to indicate the "fatuers" or degree of well being of the individual. Clark[1] (1928) found the weight length factor to reflect the fat content of the California sardine. The factor values were found to decrease from December to May for larger fish, and from December to January for the smaller. Todd (1915) found that condition in the plaice varied according to food conditions, and that the amount of molluscs available seemed to be the factor of greatest importance.

Hecht (1916) found that the weight-length relationship did not vary with increase in size, and concluded that form was constant throughout life. Tjurin (1927) found that when the relationship between length and weight has been determined and plotted on a logarithmic scale, the weight of Coregonus tuqun (Pallas) can be calculated accurately from the body length. Van Oosten (1926) found the caluculated values of the weight of lake herrings to vary only slightly from the actual values. The greatest variations of the true value from the calculated value was found in the largest size group. Menzies (1927), however, found the value of K to increase with age in the spring and summer fish groups of the Scottish salmon. He further found the longer fish within a year class to be the fatter. Clark's data on the sardine indicate the reverse: that smaller specimens within the year class are the fatter.

Average values of K for certain of the collections considered in this study appear in Tables XCII to XCVI. In comparing values for collections from different lakes and for different collections in the same lake, it is well to keep in mind the fact of seasonal variation in condition. The data here at hand afford no basis for determining the nature of such variation. For this purpose, it would be necessary to have a series of collections ranging in time throughout the entire year. The data do indicate slightly a tendency for K to increase in value as the summer proceeds.

BLUE GILLS

No definite trend of variation of K from one year class to the other is evident from the data. In 21 samples, the III class occurred along with specimens from other year groups. In 13 of the 21 cases, the III had an average value for K greater than any other year group; i. e., in 62% of the cases. Similarly, in 5 out of 20, or in 25% of the cases, the IV group held the maximum average value of K and in 2 out of 9, or 22%, the V group possessed the greatest average value. The II group appears with other year classes 5 times, but in no instance has the greatest value of K for the collection. The VI group appeared twice, but showed a maximum value for K in only one sample where the year class had only one representative. Only one specimen in the VII group was encountered. The lowest individual values for K were found in the II group.

An interesting case of an unusually high coefficient of condition was encountered in Tippecanoe Lake. A blue gill of the III group taken August 20, 1929, weighed 186 gm., although its length was only 15.9 cm. The value for K was 5.348. For the total group, the average weight was 139, and the average length 15.9 cm. The caudal peduncle was much shortened. The vertebrae of the caudal portion were reduced in size. There was no indica-

[1] This publication contains a bibliography of papers dealing with the problem of the relation of weight to length in fishes.

tion of any abnormality resulting from injury. This was the only instance of such a great variation from the average condition.

The disturbing factor of seasonal variation as affecting comparisons made at different dates from different localities has been mentioned. Although based on few specimens, the samples from Indian Village and Gordy Lakes indicate respectively a falling from April and from midwinter to July. The samples taken from Winona in 1929 indicate no consistent change in the values of K from July to early August.

Certain comparisons are, however, possible. It is obvious that the blue gills from Wawasee are uniformly in excellent condition. The August, 1929, collections from Hyndman, Tippecanoe, Dewart, Winona, and Silver Lakes were taken within a space of time small enough that they may be considered comparable. The first two show a value of K definitely higher than the last three. In the case of the five lakes of the Indian Village chain, the collections were scattered too much through the different seasons to serve satisfactorily as a basis for comparison. On the whole, the fish from Hyndman Lake seem to have the highest values for K, but it must be noted that no collections taken from any of the other lakes of that group at the same time are available for comparison.

CRAPPIES

The material on the whole is too scanty for purposes of comparison. It is of interest to note that the crappies from Little Pike Lake, which show unusually low value for K, were nevertheless the largest specimens both in weight and length encountered in any collections.

CISCOES

Since the 1928 collections were made at the spawning time, the values of K were not computed. These collections contained both spent and unspawned specimens. The specimens from the Hyndman Lake collection showed the beginning of the pre-spawning development of the gonads. This circumstance probably accounts for the higher values from this lake.

A comparison of Van Oosten's (1928) values for this species reveals striking differences.

TABLE LXXVI.

Age[1]	Lake Huron	Indian Village Lakes[2]
I and II	1.11	....
II	1.11	1.56
III	1.13	1.79
IV	1.16	1.66
V	1.19	1.69
VI	....	1.64
VII	....	1.54

[1] The ages as given by Van Oosten are modified so as to be comparable with those of the Indian Village fish.

[2] In order to render the data from the two sources comparable, I have rounded off Van Oosten's values to three significant figures, moved the decimal places two places to the right, combined the values for the two sexes, and in the cases where he presented data for more than one group of the same age, I have combined these to arrive at an average. Due to the great degree of uniformity of his data, these operations produced little alteration in the values. In his summary Van Oosten gives as the value of K for L. artedi the constant 0.01126 or 1.13 by the method of notation employed in this paper. The above modified figures for the Lake Huron ciscoes are based on data presented in Table 44, page 377 of Van Oosten's (1928) paper.

The values of K for the Indian Village fish are from 41% to 58% greater than those for the corresponding year groups from Lake Huron. Whatever the factors producing such great differences, they must be potent. First there exists, of course, the possibility of a racial difference. There is reason to believe that the Indian Village ciscoes have long existed as an isolated group. Their environment is quite unlike that of the Lake Huron group. Scott (1931) points out that the Indian Village ciscoes live under conditions of temperature and oxygen tension which have in the past been considered impossible for any members of the species. The lakes are shallow, the summer water temperature high at all depths, and oxygen is absent from the lower strata during the summer months. Circumstances which force a species to adapt itself to a new set of environmental conditions are doubtless conductive to the formation of racial differences. It should be remembered further that the Indian Village Lakes lie at a much lower latitude than does Lake Huron. There results a higher average water temperature for the more southernly lakes, and a longer growing season for their fish population. Again, feeding conditions are more favorable in the Indiana lakes as quantitative studies have brought out.

Koelz was unable to make a precise taxonomic determination on specimens sent him from Indian Village and Gordy Lakes because of the small number of individuals in the sample. He suggested that the ciscoes of these lakes are probably the same as those reported by Jordan from Lake Tippecanoe as Leucichthys artedi cisco. A racial study of the ciscoes of Indiana lakes should prove of value.

PERCH

A small collection from Winona Lake taken August 14 and 19, 1925, affords an opportunity for comparison of the first three year classes. These specimens were weighed accurately, and their lengths carefully measured by use of dividers. A marked increase in the value of K from the O to the I group is indicated. The change from the II to the III group is less pronounced.

The 1926 perch from Wawasee show a fair degree of uniformity from the II to the V group.

The small values for K in both the I and II groups of the 1929 collections is striking. The collections were made at the same part of the lake in 1927, 1928, and 1929. Hence, the 1929 II group might be considered a continuation of the 1928 I group. Nevertheless the values of K for this year group were 1.50 and 1.30 for 1928 and 1929, respectively. The opinion that environmental factors are responsible is given support through the circumstance of low values for both year classes represented in the 1929 samples.

The six perch taken from Dewart Lake August 21 and 22, 1929, were not only the largest as to weight and length taken in any collection, but also show an unusually high weight for their length.

Other Species.—The values of K for the large mouth bass, the small mouth bass, and the pickerel, respectively, in Wawasee are 2.18, 2.04, and .68. The average value of K for the various silver bass collected is 2.12.

VARIATION IN LENGTH

On the whole, the variations in length from lake to lake are not great. In making comparisons, it is well to keep in mind the number of specimens, the date of collection, and the method of capture. Tables LXXXII to XCI summarize by species the different collections.

BLUE GILLS

In length, as in weight, the Wawasee fish show better growth than those of other lakes. The advantage is first apparent in the IV group and seems to depend chiefly upon the better growth of Wawasee blue gills during and beyond the fourth summer.

It is to be noted that there is no demonstrable correlation between the average length of a sample and the average value of K. The lakes having the better grown fish with respect to length do not necessarily have the fish showing the best "condition." It is, of course, possible that the lack of correlation is only an apparent one. The collections were made over a considerable period of time, and it is further easily conceivable that the differences resulting from the method of collection might be sufficiently large to obscure variations which might be brought to light were all collections made within a short period of time and by the same gear.

There are certain food conditions in Wawasee which may in part explain continued good growth in the blue gills. It has been shown (Scott *et al.*, 1928) that, during the summer months, there is an unusually plentiful population of large Chironomid larvae, and that this population is particularly dense in a belt lying approximately between the 10 and 15 meter contour lines. That the food material is not unavailable due to chemical conditions has been demonstrated through gas analyses which show sufficient dissolved oxygen to support life easily in all except the lower strata of the region.

During July, the blue gills congregate in this region of deeper, cooler water and plentiful food supply. Those seeking to catch blue gills of a good size fish "in about forty feet of water" and with their baited hooks between one and three feet above the bottom. During the latter part of July and in August, large blue gills are seldom taken elsewhere (occasionally they can be taken on a fly). I have never known individuals smaller than those of the III group to be caught in this deep water. The stomachs of the blue gills taken in the 10-15 meter belt contain many large chironomid larvae.

Such an abundance of bottom food as occurs in Wawasee is not found regularly in other lakes. Comparison with a similar study of Tippecanoe shows that the bottom of the latter lake has a scantier supply of food forms. In this instance, the much greater supply of plankton makes up in part the deficiency. Mr. Floyd Carpenter, who has collected chironomid larvae extensively, has told me that in most lakes these forms are quite sparse as compared to Lake Wawasee.

A study of the stomach contents of blue gills[1] has showed that in July and August small crustaceans (chiefly Cladocera) constitute the chief element of their diet. Large chironomid larvae, if available in quantity, should, in the matter of size at least, be superior to small crustaceans as food for larger fish. It would be expected that the fish would avail themselves of the food

[1] From unpublished data furnished by Dr. Will Scott.

more easily taken in large quantities, and that they might congregate in the region of such an abundant food suplpy.

The excellent food conditions in Wawasee are brought forth graphically in the following table which gives the total amount of bottom food organisms in different waters. The material for the table with the exception of that concerning Lake Wawasee appears in Adamstone's (1924) report on the bottom fauna of Lake Nipigon. The values for the different zones in Wawasee were calculated from data from the report by Scott *et al* (1928) on the bottom fauna of that lake.

TABLE LXXVII.

Quantity of Food Organisms in Bottom Fauna in Different Waters

Lake	Zone (Meters)	Pounds per Acre (Dry Wt.)
Illinois River		261
Connecting lakes of Illinois River		155
Lakes N.E. Illinois		82.8
Oneida		245
Mendota	0—1	60
Mendota	1—3	64
Mendota	8—20	42.9
Green Lake	0—1	7.75
Green Lake	1—10	14.2
Green Lake	10—20	26.6
Green Lake	20—40	29.9
Green Lake	40—66	27.6
Nipigon		5.23
Wawasee[1]	0—2	218.5
Wawasee[1]	2—4	213.3
Wawasee[1]	4—23	103.0

The Illinois River with its connecting lakes, and Lake Oneida excel Wawasee in the quantity of food forms. On the other hand, Wawasee has a much richer fauna than the lakes of northeastern Illinois, Lake Mendota, Green Lake, and Lake Nipigon. The poorer fauna of the northern lakes is suggestive of the possible effect of latitude. The degree of effectiveness of that factor is, however, rendered problematic through the undoubted importance of such factors as fertility and general geological make-up of the surrounding land, the type of bottom, the plant population, and the actual form (area, slope, depth) of the different lakes.

CRAPPIES

Variation from lake to lake is not marked. As further impediments to making comparisons stand the small size of the collections and the scant representation of the year class above the III group. The largest crappies encountered were taken from little Pike Lake. Well grown crappies were also found in Winona Lake.

PERCH

Most of the perch studied were taken from Wawasee. The collections agreed well from year to year. There was also close agreement between Wawasee samples and collections of the early year classes from Syracuse,

[1] The high values for Wawasee are in part due to the presence of large numbers of molluscs particularly Goniobasis and Sphaerium which give a large dry weight.

Tippecanoe, and Winona Lakes. The largest perch studied were taken from Dewart Lake.

In many lakes, perch are found in abundance, but large ones are rare. Large perch are seldom taken in Winona or Tippecanoe. In Wawasee the individuals of greater size are fairly common, and Dewart Lake is highly reputed for its perch. It is probable that the variation in the perch fishery from lake to lakė results not so much from variations in growth rate as it does upon factors which tend to eliminate most of the individuals before they had attained an advanced age. There remain, of course, the possibilities of a change in growth rate or of habits in the adult which bring about immunity from capture by ordinary fishing methods. In the first instance, it would be difficult to account for the absence of the stunted specimens from the samples.

At this point a comparison with Harkness' (1922) results in his growth study of the yellow perch of Lake Erie is of interest. The following table gives the lengths of the different year classes in Lake Wawasee and Lake Erie.

TABLE LXXVIII.

Age	0	I	II	III	IV	V	VI	VII
Wawasee	3.9	8.6	12.9	16.7	19.8	22.0	23.0	..
Erie	4.4	.	14.4	16.8	18.7	21.7	23.4	24.4

Harkness states that his material was obtained in the summer and autumn. The perch from Wawasee were, except for a very few specimens, taken in midsummer months, and may as a whole be considered typical for July. It is likely, then, that the Lake Erie fish were taken somewhat later in the growing season. This circumstance would give them a slight advantage over the Wawasee perch, an advantage which would tend to show itself in the first few year classes but would be neglible in the older groups.

It may be seen that the trend of growth of perch in the two lakes is quite similar. The few specimens taken from Dewart Lake were better grown than any from either Erie or Wawasee.

Cisco.—The largest ciscoes were found in Gordy Lake. No consistent variation from lake to lake is apparent.

A comparison with the data presented by Clemens (1922) and Van Oosten (1928) for the same species indicates a much more rapid growth and a greater size for the Indiana fish.

The following table gives the comparison between the length values for the fish from Saginaw Bay, Lake Huron, from Lake Erie, and from the Indian Village Lakes (Indian Village, Gordy, and Hyndman).

TABLE LXXIX.

Year Class	I	II	III	IV	V	VI	VII
Saginaw Bay[1]	18.5	21.8	23.5	24.4	25.8	27.4	29.2
Erie	12.5	16.0	19.9	21.5	23.5	25.5	27.5
Indian Village		26.0	30.1	31.6	34.2	33.6	37.4

[1] These length averages are taken from Table 43, page 374 of Van Oosten's (1928) paper. The ages have been altered to make them comparable to the Indian Village fish. In the comparison the Lake Huron fish are given a slight advantage since the Indian Village samples contained some specimens which were taken in the summer, and had not completed the season's growth.

When it is remembered further that the Indian Village fish are much heavier proportionate to length than those from Lake Huron, the difference in actual size between those two groups is more striking.

The ciscoes from Lake Erie show a growth far below that of either the Bay City or the Indian Village specimens.

The matter of the possible causes of the differences has already been discussed.

OTHER SPECIES

Large Mouth Black Bass.—The collections were small and scattered. The samples from Wawasee are fairly consistent within themselves. A single XVI(?) group specimen from Papakeechie was the oldest one studied.

Small Mouth Black Bass.—The few specimens give no basis for comparison.

Longeared Sunfish.—The specimens in all collections were small and showed slow growth.

Rock Bass.—All but three of the specimens were taken from Wawasee and have been discussed previously.

White Bass.—No comparison can be based on the data at hand.

Pickerel.—A rather rapid growth is indicated in the few specimens from Wawasee.

TABLE LXXX.

Species	Year Class										
	0	I	II	III	IV	V	VI	VII	VIII	IX	XVI?
Perch	66 (9)	390 (51)	240 (32)	36 (5)	21 (3)	3 (.43)	1 (.13)				
Blue Gills		26 (4)	192 (26)	281 (39)	182 (25)	37 (5)	7 (.96)	1 (.14)			
Crappies			2 (1)	72 (47)	63 (41)	12 (8)	4 (3)				
Long-eared Sunfish		1 (3)	18 (53)	9 (26)	3 (9)	3 (9)					
Large Mouth Black Bass	9 (10)	22 (24)	4 (4)	8 (9)	29 (32)	13 (14)		2 (2)	4 (4)		1 (1)
Small Mouth Black Bass					3 (30)	1 (10)	4 (40)		1 (10)	1 (10)	
Rock Bass		26 (37)	17 (24)	9 (13)	8 (11)	7 (10)	1 (1)	3 (4)			
Silver Bass			3 (33)	6 (67)							
Cisco			3 (3)	34 (35)	33 (34)	20 (21)	4 (4)	3 (3)			
Pickerel				1 (7)	6 (40)	6 (40)	2 (13)				

REPRESENTATION OF THE DIFFERENT AGE GROUPS

Table LXXX presents the proportions of the various year groups in the total collections of the different species by both actual numbers and percentages. To a large extent the figures are of no value for comparison, being largely the results of the different methods of sampling. The data are presented merely to show the actual age composition of the collections and to indicate the relative scarcity of older specimens. Groups taken by the same fishing methods may, however, be compared.

Perch.—The I and II groups were taken for the most part by the same method, but are not comparable with older year classes. There is a 37% decrease in numbers from the second to the third summers. Among the older groups it will be noticed that fish more than four years old are rare.

Blue Gills.—The smaller individuals of the III group could doubtless pass through the net. The proportion of this year class with respect to the older groups should, then, be larger. There is a marked falling off from the IV to the V group, and specimens above the latter age are quite rare.

Crappies.—Here as with the blue gills it is likely that the smaller III group specimens escaped the net. Fish above four years of age are not numerous.

Longeared Sunfish.—The few specimens at hand were not taken by any one method.

Large Mouth Black Bass.—They are well represented in the IV and V groups. Some, it seems, survive to a quite respectable age. The net used could not take the large specimens. The lower limit of selection is uncertain, but it is probable that the III group was affected most.

Small Mouth Black Bass.—All were taken on a casting rod. The data are almost negligible, but it is probable that the age distribution is similar to that of the large mouth bass.

Rock Bass.—Specimens beyond the V group were scarce. On the whole, the situation resembles that of the blue gills and crappies.

Silver Bass.—No adequate data are available. For this species the individuals studied are quite small.

Cisco.—All groups, except for selection by the net, are well represented as far as the six year old fish. The greatest drop in numbers comes from the V to the VI group.

Pickerel.—It is certain that individuals of this species reach an age well beyond that of any of the specimens studied here. While the largest pickerel taken in any of my collections weighed only about eight pounds, some individuals are known to grow to a weight greater than twenty-five pounds. By virtue of their size, these large fish are seldom taken.

AGE AND LEGAL LENGTH LIMITS

The legal length limits for the different species studied in this paper, as fixed by the fish and game laws of the state of Indiana are:

Blue Gill	5 in.
Rock Bass	5 in.
Black Crappie	6 in.
Longeared Sunfish	5 in.
Large Mouth Bass	11 in.
Small Mouth Bass	11 in.
Silver Bass	10 in.
Ringed Perch	7 in.
Pickerel	15 in.
Cisco	none

The limits are for total length, not for standard length.

Blue Gills.—The legal length is attained in the third growing season (II group). No specimens were taken earlier in the season than in late June. At this time, almost all are of legal size. No. I group specimens encountered were of legal length; nor were any III group individuals below five inches.

Rock Bass.—Here the conditions are similar to those of the blue gill. The individuals of the II group are somewhat slower in reaching the required length than in the blue gills, but all are above five inches in the III group samples.

Black Crappies.—The two youngest specimens examined were members of the II group taken from Winona Lake. Both were above six inches. They must have attained legal length early in the third summer.

Longeared Sunfish.—It is doubtful whether legal size is reached before the fourth growing season, and some individuals in the III, IV, and V groups will scarcely pass the scrutiny of the law.

Ringed Perch. The legal size of seven inches is not reached before the third summer (II group). The collections of this year group are composed of a mixture of individuals below and above legal length. The percentage above seven inches increases as the season advances. In the III group collections, practically all specimens are above legal length.

Large Mouth Black Bass.—A collection from Wawasee taken in April, 1929, showed that at the beginning of the fifth summer almost all of the individuals were above eleven inches. It is probable that in Wawasee most large mouth bass reach legal size during the fourth summer (III group). There is little data from other lakes, but they probably do not vary much from the conditions found in Wawasee.

Small Mouth Black Bass.—The youngest individuals examined were taken at about the middle of the fifth growing season (IV group). They were above legal size.

Juday and Schneberger (1930) report that in the Wisconsin lakes where the length limit is ten inches, "the large and small mouth bass rarely reach a length of ten inches before the fifth year and only 25% to 50% of them attain that size in the fifth year. Even some of the six year old specimens

had not reached that length." Their report indicates a better growth for the black bass in Indiana lakes.

Silver Bass.—It is difficult to make a determination from the few specimens at hand. It appears that the silver bass is of legal size in its fourth summer (III group), and that that size may possibly be attained in the third summer.

Pickerel.—The single specimen of the III group was under legal size while those of the IV group were above that size. It would appear that legal length is attained late in the fourth growing season or early in the fifth.

Cisco.—Since this fish is rarely taken except in nets, the law prohibiting netting makes a size protection unnecessary.

SUMMARY

1. This growth study is based upon 1,955 specimens, including 10 species and collected from 20 lakes in three drainage areas.

2. The determination of the ages was based upon a study of the scales. The validity of the method is assumed on the basis of investigations which have been made by previous workers.

3. The data presented include age, length, weight, and, in some instances, the value of K (coefficient of condition).

4. Tables are presented showing comparative lengths of the various species in the different collections. On the whole, the variation from lake to lake is not great. In many instances, the agreement between different lakes is very close. The blue gills from Lake Wawasee enjoy a growth above the average. The better size attained by the Wawasee fish seems to result from continued good growth in the fourth and succeeding summers. The method of obtaining the sample exerts considerable influence on the nature of the sample.

5. Increments of growth for periods within the growing season were determined in the I and II groups of the perch in Lake Wawasee for the summers of 1927, 1928, and 1929.

6. The value of K depends partly on the date of collection. Certain lakes nevertheless show a definitely higher value for K for blue gills than do others.

7. No definite trend is apparent in comparing values for K in the different year groups. In the blue gills, where no data below the II group were available, the maximum value for K occurred most frequently in the III group. A small collection of perch from Winona Lake indicated a distinct rise in the value of K from the O to the I group.

8. The collections of I and II group perch from Wawasee show considerable variation in the value of K from year to year. The average values for these year groups in the 1929 samples are greatly below those of the three preceding years. The length averages for these fish are the equal of those of previous seasons.

9. Food conditions affecting the older fish are suggested as a possible factor in the continued good growth of the older blue gills from Lake Wawasee.

10. The greater number of the larger blue gills and crappies belonged to the III group. Members of the IV group were usually found, while those of higher groups were rare. The maximum age group encountered for each of

the ten species was: blue gill, VII; crappie, VI; longeared sunfish, V; rock bass, VII; large mouth black bass, XVI(?); small mouth black bass, IX; silver bass, III; cisco, VII; pike, VI; yellow perch, VII.

11. Comparisons with growth data presented by Wright (1929) on the rock bass and by Clemens (1922) and Van Oosten (1928) on the cisco (lake herring) indicate that the Indiana fish grow more rapidly and attain a greater size. In the case of the lake herring, the values of K were in each age group more than 40% higher for the Indiana than for the Huron fish. Juday and Schneberger's (1930) report on the game fishes of Wisconsin lakes indicates that the large and small mouth black bass grow more rapidly in Indiana lakes. A suggested explanation is that the difference in latitute produces a corresponding difference in factors influencing growth—average water temperature, food conditions, and length of the growing season—with the Indiana fish living under the more favorable conditions.

Relatively close agreement in the nature of growth is found between the yellow perch of Lake Erie (Harkness, 1922) and Lake Wawasee.

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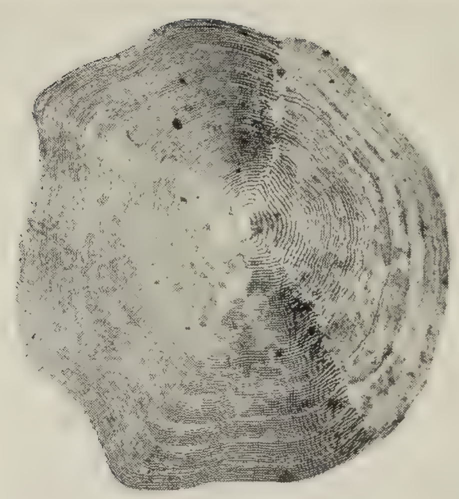

FIG. 1. Scale of Cisco. Age V. The growth area outside the fifth annulus indicates the growth of the sixth year. The fish was taken in the early winter.

FIG. 2. Scale of a Perch. Age I. A large growth is indicated in the second summer.

FIG. 3. Scale of Perch. Age VI. In this scale there is a dark band in the region of each annulus.

FIG. 4. Scale of Perch. Age IV.

APPENDIX

TABLE LXXXI.
TOTAL COLLECTIONS BY LAKES

Lake	Blue Gill	Black Crappie	Long-eared Sunfish	Rock Bass	Large Mouth Black Bass	Small Mouth Black Bass	Silver Bass	Cisco	Pickerel	Yellow Perch	Total
Syracuse	28		9	12	15					21	85
Wawasee	157	13	3	56	53	10			5	635	932
Papakeechie	3	2			4					1	10
Indian Village	47	15			2			62			126
Duley	53	8									61
Rider	24	6			1						31
Gordy	34							24			58
Hyndman	46							11			57
Dewart	45	7			1					6	59
Spear	1	2			3						6
Ridinger	3	3									6
Dan Kuhn	4										4
Big Barbee	20	10									30
Little Barbee	14	6									20
Tippecanoe	32	6		2	8		5			61	114
Little Chapman	25										25
Pike	5	5					1		1		12
Little Pike	9	12			1		3		7		32
Center	18	1									19
Winona	133	55	22	1	5				2	33	251
Silver	15	2									17
Total	716	153	34	71	93	10	9	97	15	757	1955

TABLE LXXXII.
LENGTH VALUES FOR CISCOES

Lake	Date	Year Class					
		II	III	IV	V	VI	VII
Indian Village	11–26–28	25.7 (1)	30.4 (19)	31.9 (15)	32.7 (8)		33.3 (1)
Indian Village	7–21–29			32.4 (9)	33.4 (7)	33.4 (2)	
Gordy	–11–28 12– 1–28	26.4 (1)	29.7 (12)				
Gordy	7–23–29			31.8 (4)	37.7 (5)		39.4 (2)
Hyndman	8–12–29 8–13–29	26.0 (1)	29.4 (3)	29.0 (5)		33.8 (2)	

TABLE LXXXIII.
LENGTH VALUES FOR PICKEREL

Lake	Date	Year Class			
		III	IV	V	VI
Wawasee	7–18–26	30.3 (1)			
Wawasee	Apr., 1929		48.3 (1)	69.8 (2)	83.7 (1)
Pike	July, 1929		53.5 (1)		
Little Pike	July, Aug. 1929		45.7 (4)	45.0 (2)	54.6 (1)
Winona	July, 1929			67.8 (2)	

TABLE LXXXIV.
LENGTH VALUES FOR CRAPPIES

Lake	Date	Year Class				
		II	III	IV	V	VI
Wawasee....	7–25–27			20.6 (1)		
Wawasee....	7– 5–29		18.3 (8)	19.4 (4)		
Indian Village	4–23–29			18.5 (8)	20.6 (3)	20.8 (1)
Indian Village	7–21–29		18.3 (3)			
Duley....	4–23–29			18.0 (8)		
Rider...	6–22–29		18.8 (6)			
Dewart..	......		18.6 (7)			
Papakeechie	8– 8–26				10.8 (1)	20.3 (1)
Spear...	7– 5–29		19.4 (2)			
Ridinger	6–20–29		19.0 (3)			
Big Barbee..	7–15–29					
	7–29–29		18.4 (6)	19.3 (4)		
Little Barbee..................	7–13–29					
	7–30–29		17.7 (2)	18.5 (3)	20.0 (1)	
Tippecanoe....	8–19–29					
	8–20–29		19.1 (2)	19.4 (4)		
Pike......	July, 1929		19.8 (5)			
Little Pike	July, Aug., 1929			19.6 (6)	22.3 (4)	24.2 (2)
Center...	7–21–29		18.7 (1)			
Winona..	8–19–25	15.6 (1)				
Winona...	July, Aug., 1929	14.9 (1)	18.3 (25)	21.2 (25)	22.8 (3)	
Silver....			17.6 (2)			

TABLE LXXXV.
LENGTH VALUES FOR ROCK BASS

Lake	Date	Year Class						
		I	II	III	IV	V	VI	VII
Syracuse.........	7– 7–27							
	7–18–27	5.9 (4)	10.0 (8)					
Wawasee..	1926		14.2 (3)	17.0 (1)		22.7 (1)	23.3 (1)	
Wawasee.......	1927	5.6 (14)	10.5 (5)	14.5 (5)	17.8 (4)	18.4 (2)		23.4 (2)
Wawasee	1928	5.1 (5)	9.7 (1)	14.6 (1)	18.6 (4)	20.3 (1)		21.9 (1)
Wawasee.........	6–18–29							
	7– 1–29	5.1 (1)		17.2 (1)		21.8 (1)		
Tippecanoe	7–19–27			14.6 (1)		17.0 (1)		
Winona...	7–31–26					17.0 (1)		

TABLE LXXXVI.
LENGTH VALUES FOR LONGEARED SUNFISH

Year Class	Syracuse 7–8–27	Wawasee 7–4–27	Wawasee 6–28–28	Winona 6–22–27 6–27–27	Winona 7–14–29
I	6.4 (1)				
II	9.2 (5)	7.5 (1)	7.5 (1)	7.3 (9)	7.7 (2)
III	10.0 (1)	11.1 (1)		8.1 (4)	11.2 (3)
IV	11.1 (1)			9.2 (2)	
V	12.4 (1)			9.4 (2)	

TABLE LXXXVII.
LENGTH VALUES FOR BLUE GILLS

Lake	Date I	Year Class II	III	IV	V	V	VI	VII
Syracuse	7–3–26	...	11.2 (19)	17.3 (1)	17.1 (1)	17.6 (1)	...	...
Syracuse	7–8–27	5.1 (2)	9.7 (4)	...	...	...	...	...
Wawasee	July, Aug., 1926	...	11.4 (77)	15.5 (14)	18.4 (14)	19.3 (7)	21.0 (1)	...
Wawasee	July, 1927	5.3 (14)	9.8 (7)	20.2 (2)	...	...	...	...
Wawasee	6–30–28	...	...	14. (1)	17.2 (2)	18.2 (6)	20.3 (1)	...
Wawasee	Apr., 1929	...	...	15.6 (4)	16.6 (2)	...	19.7 (1)	...
Wawasee	6–18–29 7–5–29	...	...	15.4 (2)	19.7 (1)	20.0 (1)	...	...
Indian Village	4–23–29	...	...	15.9 (3)	16.6 (28)	18.4 (3)	...	...
Indian Village	7–21–29	...	...	16.4 (9)	18.0 (3)	18.1 (1)	...	...
Duley	4–23–29	...	...	15.8 (2)	16.3 (42)	16.9 (5)	17.6 (3)	19.1 (1)
Rider	6–20–29	...	...	15.8 (15)	16.9 (7)	18.7 (2)	...	...
Gordy	11–26–28	...	14.5 (2)	16.7 (6)	...	18.3 (1)	...	...
Gordy	7–23–29	...	...	15.9 (9)	17.5 (14)	18.7 (2)	...	...
Hyndman	8–12–29 8–13–29	...	...	16.3 (33)	17.1 (11)	19.3 (2)	...	...
Dewart	8–21–29 8–22–29	...	...	16.0 (35)	17.7 (10)	...	...	...
Papakeechie	8–8–26	...	...	...	...	14.7 (2)	15.7 (1)	...
Spear	7–5–29	...	...	17.0 (1)	...	...	...	...
Dan Kuhn	7–31–29	...	...	16.6 (2)	17.6 (2)	...	...	...
Big Barbee	7–15–29 7–29–29	...	...	15.8 (16)	17.8 (4)	...	...	...
Little Barbee	7–13–29 7–30–29	...	...	15.6 (13)	17.6 (1)	...	...	...
Tippecanoe	8–20–29 8–21–29	...	...	15.9 (25)	18.0 (4)	18.6 (3)	...	...
Ridinger	6–20–29	...	...	16.6 (3)	...	...	...	...
Little Chapman	7–6–29	...	...	15.9 (12)	16.9 (13)	...	...	...
Pike	July, 1929	...	...	15.9 (5)	...	...	...	...
Little Pike	July, Aug., 1929	...	...	15.2 (6)	16.1 (3)	...	...	...
Center	7–2–29	...	...	15.6 (15)	16.5 (3)	...	...	...
Winona	Aug., 1926	8.0 (1)	11.6 (3)	...	...	...	...	...
Winona	July, 1929	8.7 (7)	11.6 (36)	15.0 (10)	17.5 (5)	19.1 (1)	...	...
Winona	Aug., 1929	9.1 (2)	11.6 (44)	15.1 (13)	16.6 (11)	...	...	...
Silver	8–10–29 8–17–29	...	...	16.5 (14)	18.3 (1)	...	...	...

TABLE LXXXVIII.
LENGTH VALUES FOR SMALL MOUTH BASS

Year Class	Wawasee July, 1926	Wawasee July, 1927
IV	...	27.4 (3)
V	27.3 (1)	...
VI	33.7 (1)	31.8 (3)
VII	...	...
VIII	...	41.0 (1)
IX	37.8 (1)	...

TABLE LXXXIX.
LENGTH VALUES FOR LARGE MOUTH BASS

Lake	Date	Year Class								
		O	I	II	III	IV	V	VII	VIII	XVI
Syracuse	7- 8-27	3.7 (1)	9.5 (13)	14.0 (1)						
Wawasee...	7-1926						34 0 (1)		38.1 (1)	
Wawasee..	7-1927		10.6 (4)		22.6 (3)	27.7 (1)	30.9 (6)			
Wawasee...	6-19-28 6-30-28			14.8 (2)						
Wawasee...	7-14-28		8.4 (5)	16.5 (1)						
Wawasee...	4-1929					26.2 (19)	29.2 (2)			
Wawasee...	6-18-29 7- 5-29				25.1 (5)	27.4 (2)				
Indian Village	4-23-29					24.1 (1)				
Indian Village.	7-23-29					24.1 (1)				
Rider....	....						27.5 (1)			
Papakeechie.	1926					22.3 (1)			37.2 (1)	44.5 (1)
Papakeechie.	4-21-29								37.5 (1)	
Spear......	4-21-29						27.0 (1)	31.4 (1)		
Spear....	6-27-29					26.0 (1)				
Dewart...	8-22-29					27.6 (1)				
Tippecanoe...	7-19-27	3.5 (8)								
Little Pike.	7-10-29					26.4 (1)				
Winona...	7- 4-26					32.4 (1)				
Winona...	7- 4-27							40.6 (1)		
Winona.......	7-26-27 8-17-27						33.0 (1)		40.6 (1)	
Winona	7- 4-29						40.3 (1)			

TABLE XC.
LENGTH VALUES FOR PERCH

Lake	Date	Year Class						
		O	I	II	III	IV	V	VI
Syracuse........	7- 3-26			14.7 (2)				
Syracuse.......	7- 2-27	4.2 (3)	9.6 (12)	11.1 (4)				
Wawasee......	July, Aug., 1926		9.4 (5)	13.7 (25)	16.6 (27)	19.4 (9)	22.0 (3)	
Wawasee.......	7- 7-27	3.3 (5)	8.3 (27)	13.0 (11)				
Wawasee.......	7-14-27	3.4 (4)	8.8 (153)	13.4 (38)	16.8 (2)			
Wawasee.......	7-28-27		9.2 (36)	13.8 (18)				
Wawasee.....	8-17-27			14.9 (3)				
Wawasee.....	6-19-28 6-20-28		7.4 (21)	11.7 (18)				
Wawasee......	6-28-28		7.7 (5)	12.1 (14)	15.6 (2)	20.2 (2)		
Wawasee.......	6-30-28		7.9 (25)	12.0 (74)	19.1 (1)	20.4 (2)		
Wawasee.....	8-14-28	4.4 (10)	9.0 (26)					
Wawasee.....	10-10-28 10-11-28			16.4 (7)	17.2 (3)	20.5 (2)		
Wawasee.....	7- 1-29		8.1 (38)	13.5 (18)	16.4 (1)			
Papakeechie...	8- 8-26							23.0 (1)
Dewart........	8-21-29 8-22-29					26.4 (6)		
Tippecanoe.....	7-19-27	4.1 (29)	9.8 (32)					
Winona........	8-14-25 8-19-25	5.2 (15)	8.6 (10)	12.2 (8)				

TABLE XCI.
LENGTH VALUES FOR SILVER BASS

Year Class	Tippecanoe 8-20-29 8-21-29	Little Pike July, 1929	Pike 8-6-29
II	22.1 (2)		25.1 (1)
III	26.0 (3)	28.6 (3)	

TABLE XCII.
VALUES OF "K" FOR CISCOES

Year Class	Indian Village 7–21–29	Gordy 7–23–29	Hyndman 8–12–29, 8–13–29
II	...	...	1.56 (1)
III	...	...	1.79 (2)
IV	1.62 (16)	1.66 (4)	1.77 (5)
V	1.65 (2)	1.64 (5)	2.06 (1)
VI	1.60 (6)	...	1.90 (1)
VII	...	1.54 (2)	...

TABLE XCIII.
VALUES OF "K" FOR CRAPPIES

Lake	Date	Year Class				
		II	III	IV	V	VI
Wawasee	6– 8–29 7– 5–29	...	2.50 (9)	2.59 (4)	...	...
Indian Village	4–23–29	...	...	2.66 (8)	2.62 (3)	3.19 (1)
Indian Village	7–21–29	...	2.47 (3)	...	...	...
Duley	4–23–29	...	...	3.08 (8)	...	...
Rider	6–20–29	...	2.29 (6)	...	...	...
Dewart	8–21–29 8–22–29	...	2.58 (7)	...	...	...
Ridinger	6–20–29	...	2.43 (3)	...	...	...
Little Barbee	7–17–29 7–30–29	...	2.29 (2)	2.46 (3)	...	...
Big Barbee	7–15–29 7–29–29	...	2.32 (6)	2.36 (4)	...	...
Tippecanoe	8–19–29 8–20–29	...	2.67 (2)	2.44 (4)	...	...
Pike	July, 1929	...	2.47 (5)	...	...	...
Little Pike	July, Aug., 1929	...	...	2.17 (6)	1.93 (4)	2.26 (2)
Winona	July, 1929	2.27 (1)	2.33 (11)	2.41 (10)	...	...
Winona	Aug., 1929	...	2.44 (14)	2.59 (9)	2.55 (3)	...
Silver	...	2.46 (2)	...	...	...	...

TABLE XCIV.
VALUES OF "K" FOR ROCK BASS

Year Class	Wawasee		
	July, 1926	July, 1927	Year June, 1928
II	3.54 (1)	3.14 (4)	...
III	3.45 (4)	3.26 (5)	3.53 (1)
IV	3.53 (1)	3.32 (4)	3.18 (3)
V	...	3.77 (1)	3.53 (1)
VI	3.14 (2)	...	...
VII	...	2.94 (3)	...

TABLE XCV.
VALUES OF "K" FOR BLUE GILLS

Lake	Date	Year Class					
		II	III	IV	V	VI	VII
Syracuse	7-3-26	3.42 (19)	3.18 (1)	3.22 (1)	3.57 (1)	...	...
Wawasee	July, 1926	3.27 (68)	3.37 (14)	3.33 (10)	3.39 (7)	3.53 (1)	...
Wawasee	Apr., 1929	...	3.42 (1)	3.18 (4)	...	...	...
Wawasee	6-8-29 7-9-29	...	4.06 (2)	3.81 (1)	...	...	...
Indian Village	7-23-29		3.27 (3)	3.26 (28)	2.98 (3)	...	...
Indian Village	7-21-29		3.04 (9)	3.11 (3)	...	...	...
Duley	4-23-29	...	3.32 (2)	3.18 (42)	3.20 (5)	3.24 (3)	3.14 (1)
Rider	6-20-29	...	3.23 (15)	3.24 (7)	3.14 (2)	...	...
Gordy	11-26-28	3.09 (1)	3.23 (1)	...	3.75 (1)	...	...
Gordy	7-23-29	.	3.11 (9)	3.08 (14)	3.04 (2)	...	...
Hyndman	8-12-29 8-13-29	.	3.44 (33)	3.23 (11)	3.14 (2)	...	...
Dewart	8-21-29 8-22-29		3.15 (35)	2.90 (10)	...	...	...
Ridinger	6-20-29		2.85 (3)	...	...	...	...
Bib Barbee	7-15-29 7-29-29		3.22 (16)	3.15 (4)	...	...	...
Little Barbee	7-17-29 7-30-29	...	3.13 (12)	3.12 (1)	...	...	...
Tippecanoe	8-19-29 8-20-29		3.54 (25)	3.45 (4)	3.51 (3)	...	...
Little Chapman	7-8-27	...	3.08 (12)	3.15 (15)	...	...	...
Pike	July, 1929		3.14 (5)	...	...	...	...
Little Pike	Aug., 1929	...	3.44 (6)	3.12 (3)	...	...	...
Center	7-2-29	...	3.33 (15)	3.34 (3)	...	...	...
Winona	June, July, 1929	2.62 (15)	3.07 (8)	2.72 (16)		...	...
Winona	Aug., 1929	2.72 (41)	3.02 (13)	3.05 (11)	...	...	...
Silver	8-10-29 8-17-29	.	3.02 (14)	2.66 (1)	...	...	...

TABLE XCVI.
VALUES OF "K" FOR PERCH

Year Class	Winona 8-14, 19-25	Wawasee July, 1926	Wawasee 1927	Wawasee 1928	Wawasee 1929	Dewart 8-21, 22-29
0	1.34 (15)	...	...	...	...	...
I	1.51 (10)	...	1.54 (216)	1.50 (77)	1.34 (38)	...
II	1.56 (8)	1.69 (25)	1.70 (70)	1.63 (201)	1.30 (18)	...
III	.	1.60 (27)	...	...	...	...
IV	...	1.77 (9)	...	...	...	1.91 (6)
V		1.70 (3)	...	...	...	...

III. THE LAKES OF NORTHEASTERN INDIANA

by

WILL SCOTT

CONTENTS

INTRODUCTION

This study is concerned with the principal lakes of four counties of northeastern Indiana, i. e., Steuben, LaGrange, Noble, and Whitley. Not all the lakes of these counties have been examined, but the number studied includes all types and gives a fair and sound picture of conditions in this region. The summer of 1929 was devoted to the lakes of Steuben County. A temporary camp and laboratory was set up at the state park on Lake James. The central location of this point and the special interest attaching to Lake James made this location very advantageous. In 1930 the lakes of the other three counties were reached from the Biological Station of Indiana University. A smaller number of lakes were examined in 1930 because the lakes were farther apart and the consequent travel greater.

It is frankly an exploratory study. Dr. W. M. Tucker, working for the Department of Conservation, had mapped Lakes James, Snow, Crooked, Clear, and Gage in Steuben County; Adams and Oliver Lakes in Noble County; and Crooked, Shriner, and Round Lakes in Whitley County. Other than this nothing was known of this group except the incidental work done on them by Dayer in his work on the topography and glaciation of the region, and the mere superficial descriptions of some of them by various people.

It is well known that the summer temperature and the consequent distribution of dissolved oxygen, and carbon dioxide together with the amount of carbonates in a lake are fundamental elements in their economy. This together with the summer plankton gives a fair picture of the nature of any lake.

These facts have been determined and expressed in a series of 68 tables. These data are discussed in the body of the paper and some deductions are made. Certain difficulties have been met. The most important is the lack of topographic maps of the region. Problems connected with the carbonates are intimately related to the topography and their solution awaits the construction of such maps. A minor difficulty has been the naming of the lakes discussed in the paper. The same lake often has more than one name; for instance, Hamilton and Fish refer to the same lake, as do Garden and Golden. The same name is often applied to different lakes. The name Crooked is applied to rather important lakes in both Steuben and Whitley Counties. To obviate this difficulty a table is introduced giving the township, range, and sections occupied in part or in whole by each lake.

ACKNOWLEDGMENTS

It is a pleasure to acknowledge the hearty coöperation of the late George N. Mannfield, Superintendent of the Division of Fish and Game, and of his successor Walter Shirts, a man of sound judgment.

The field assistants in 1929 were Herman T. Spieth, Raymond J. Myers, and Ancil D. Holloway. In 1930 they were Raymond J. Myers and Mychyle W. Johnson. Their careful work adds much to the quality of the results.

In the laborious work of counting the plankton, I was assisted by Miss Mary I. Spilman and Miss Lois E. Smith. I am also indebted to Dr. Harold T. Davis and Miss Anna Mae Lescisin of the Department of Mathematics for calculating the coefficient of correlation between the carbonates and certain diatoms.

The Graduate School of Indiana University furnished funds for the apparatus and incidental expenses. I am especially grateful to Dr. Fernandus Payne, its Dean and my colleague, for his kindly encouragement.

TABLE No. 1. Location of lakes by township, range, and section. The serial numbers at the left correspond to the numbers on fig. 1, which is the map of the four counties.

Lake	TN	RE	Sec.
1. Adams, Lagrange	36	10	23-24-25-26
2. Cedar, Lagrange	38	10	21-22
3. Cedar, Whitley	32	9	2-11-12
4. Center, Steuben	37	13	22
5. Clear, Steuben	38	15	17-18-19-20-29-30
6. Crooked, Steuben	37 37	13 12	6-7-8-9-16-17 1
7. Crooked, Whitley	32 33	9 9	3-4 33-34
8. Fox, Steuben	37	13	28-33-34
9. Gage, Steuben	38 37	12 12	34-35 2
10. George, Steuben	38	13	14-15+Mich.
11. Golden, Steuben	36 36	12 12	1 5 6-8
12. Hamilton, Steuben	36	14	28-33-21-27
13. Hog, Steuben	38	13	17+Mich.
14. Hogback, Steuben	37 37	12 13	25-36 31
15. James, Steuben	38 37	13 13	28-33-34 3-4-10
16. Jimerson, Steuben	38 37	13 13	30-31-32 5
17. Lake Pleasant, Steuben	38 38	13 12	18- 12-13+Mich.
18. Long, Lagrange	36	11	22-26-27
19. Long, Steuben	36	13	15-16
20. Loon, Steuben	37	13	20
21. Marsh, Steuben	38	13	25
22. Oliver, Lagrange	36	10	17-18-19-20
23. Otter (L.), Steuben	38	13	26-27
24. Otter (U.), Steuben	38	13	26-27
25. Pleasant L., Steuben	36	13	22-23-14-15
26. Pretty, Lagrange	36	11	15-16
27. Round, Whitley	32	9	12
28. Shriner, Whitley	32	9	2-11-12
29. Silver, Steuben	37	13	29-30-31-32
30. Snow, Steuben	38	13	21-22-27-28
31. Big Turkey {Lagrange Steuben	36 36	12 11	7-18 13
32. Twin (N.), Lagrange	38	9	23
33. Twin (S.), Lagrange	38	9	26-27
34. Wallen, Noble	35	13	13

TN—Township North.
RE—Range East.
SEC.—Section.
Serial numbers indicate lake names on map No. 1.

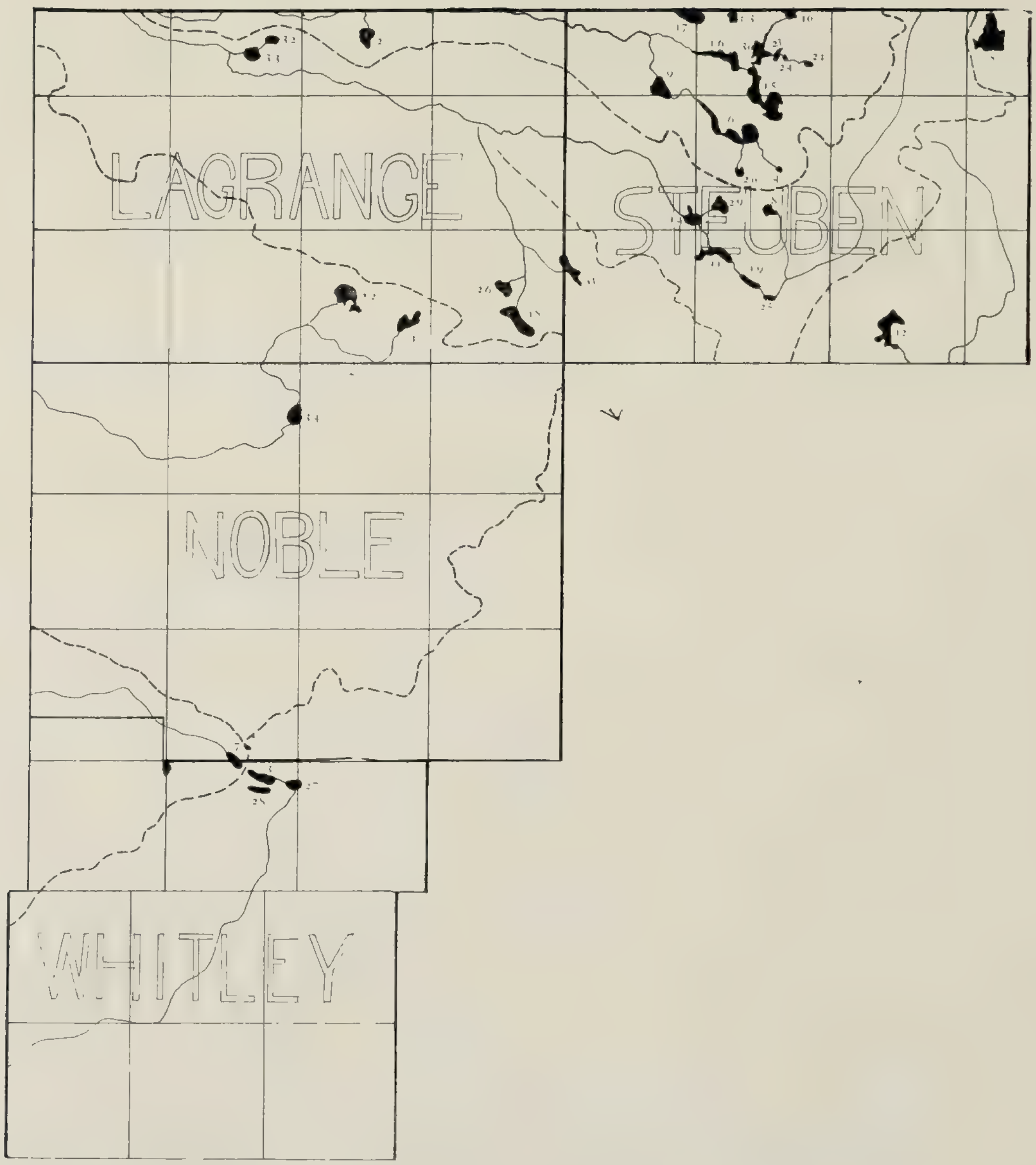

FIG. 1. Map of the area. Figures refer to lake names in Table No. 1.

DRAINAGE

The four counties Steuben, LaGrange, Noble, and Whitley, which include the lakes of this report, form a "parting of the ways" so far as surface drainage is concerned. From them the waters may go to Lake Erie through the Maumee, to Lake Michigan through the St. Joseph of Michigan, or to the Gulf of Mexico through the tributaries of the Wabash which in turn empties into the Ohio and thence to the Mississippi and the Gulf.

In Whitley County, Cedar, Shriner and Round Lakes are drained by the Eel River, which is tributary to the Wabash. Over a low divide is Crooked Lake of Whitley County, which empties into the Wabash through the Tippecanoe River.

Adams and Oliver Lakes of LaGrange County and Wallen Lake of Noble County are tributary to the Elkhart River. Fox, Pleasant, Long, Golden, and Silver Lakes of Steuben County; Big Turkey Lake of Steuben and LaGrange Counties; and Long, Pretty, North Twin, and South Twin Lakes of LaGrange County all empty into the Pigeon River.

Faun River drains two series in Steuben County. The first series is composed of Marsh, Upper Otter, Lower Otter, George, Snow, James, and Jimerson Lakes. The second consists of Center, Loon, Crooked, and Gage. In addition to this, the Faun River drains Cedar Lake of LaGrange County. These three rivers, the Elkhart, the Pigeon, and the Faun, are tributaries of the St. Joseph River of Michigan. The St. Joseph also drains Lake Pleasant and Hog Lake. The outlet of Clear Lake flows northwest and south through Michigan and Ohio to St. Joseph of the Maumee. Hamilton reaches the same stream through Fish Creek.

GLACIATION AND LAKE FORMATION

The lakes of this region are due to the Pleistocene glaciation. While much glacial drift was undoubtedly brought into Indiana by the earlier ice advances, the present distribution and topography are due to the last or Wisconsin ice sheet. This ice sheet advanced into Indiana in three great lobes, which were given direction by the basins of Lake Michigan, Saginaw Bay of Lake Huron, and the combined influences of Lakes Huron and Erie. Consequently, these lobes are called the Michigan, the Saginaw, and the Huron-Erie. Of these three lobes the Huron-Erie advanced into the northern part of eastern Indiana from the northeast; the Michigan lobe advanced into western Indiana from the north, and between these two came the Saginaw Lobe. The influence of the Michigan Lobe is outside the area considered in this paper and will not be discussed.

Leverett (1915) has determined that the Saginaw Lobe retreated first. The general climatic conditions at the same latitude must have been uniform over all three lobes. The early retreat of the Saginaw indicates that it had less mass and power than the other two. This fact and the form of the moraines (Leverett, L. C., map No. VI.) indicate that ice derived from the Saginaw lobe did not extend south of the present Wabash River nor its major tributary, the Eel River.

This massive system of moraines extends from the northeast corner of the state southwest for about seventy-five miles. In this mass occur the lakes which are discussed in this paper. While Dryer (1891, pp. 114-120) and Leverett (l. c.) attribute most of this material to the work of the Huron-Erie lobe, the region must be regarded as interlobate in the sense that both lobes influence it.

From this mass which coalesces in Steuben and a part of Noble and DeKalb Counties, there extends southwest three limbs. The eastern one is the ill defined Salamonie moraine, the middle one becomes the Mississinewa. Both of these are clearly terminal moraines of the Huron-Erie lobe.

The third and western of these three extends to the southwest, paralleling the Eel River from Whitley County to Logansport. It was along this western mass and in the coalesced moraines from Whitley County to the northeast that the great ice lobes were in contact at the time of the maximum development of the Saginaw lobe. Not only did each contribute material from its lateral and terminal moraine, but as the opposing masses varied both in thickness and force, there must have been local over-riding of one mass by the other. For reasons already given, the Huron-Erie usually did the overriding. This resulted in buried masses of ice which eventually, on melting, caused lake beds and outwash channels.

In the case of Tippecanoe Lake and the Barbee system, it was determined (Scott, 1915, p. 5) that the drainage lines were between finger-like lobes of ice. Great water-laid deposits were laid down between masses of ice. When the ice melted, the anomalous condition was produced, namely, lakes separated by water-laid ridges.

Dryer (1891, p. 133) accurately describes the condition in Steuben County as two great moraines running northeast to southwest and the streams running to the northwest. Three of these streams follow channels through the western and more massive of these two moraines. His interpretation that these channels antedate the moraines is incorrect. Also his interpretation that they formed outwash channels from the Huron-Erie Lobe is untenable, unless it is assumed that there were great masses of stagnant ice underlying these water courses and that the subsequent melting of these ice masses caused the lakes now found in these valleys.

The accurate interpretation of this whole interlobate region must await detailed studies. These studies must include the making of a topographic map, the correlation of the logs of wells, study of the water stratified drift, outwash channels, and the identification of the materials of the deposits and their point of origin. Until these data are at hand speculation as to details is futile.

CARBONATES

These lakes are all relatively hard water lakes. The "hardness" is due to carbonates, chiefly those of calcium, although a smaller amount of magnesium is usually present. These carbonates vary from 24.96 cc. of carbon dioxide per liter in Loon Lake to 54.73 in Golden Lake.

The carbonates are leached from the glacial deposits above the lake levels, and their primary source is the limestones and dolomites of the Devonian and

Silurian deposits to the northeast. They are found on the shores of Lakes Huron and Erie, on the east side of the "thumb" of Michigan, in Ohio, and in southern Ontario. These glacial deposits are very heterogenous. Many analyses will have to be made before any significant average is obtained. Collections fifteen to twenty feet below the surface in a fresh gravel pit near Winona Lake averaged 9.4% of calcium carbonate. Besides this little known factor, the amount of carbonate in the moraines, two processes seem to influence the amount of carbonates in a lake, namely, the leaching of the carbonates from the moraine above the lake level and the precipitation by photosynthesis of the carbonates from the lake water as marl. The first of the processes increases the carbonates while the second reduces it in amount. When a lake is perched high in the moraines, the water is softer than when the level of the lake is much lower than the surrounding moraines. For instance, near the divide between the Faun and Pigeon Rivers lie Center and Loon Lakes on one side, and Fox and Silver Lakes on the other. Their carbonates average respectively 31.92, 24.96, 29.72 and 31.26.

At lower elevations in this same moraine and river valleys lie Long, Garden, and Hogback Lakes on one side and Marsh, Otter and James on the other—whose carbonates average 52.39, 54,73, 44.49, 47.25, 45.96 and 38.00, respectively.

This is illustrated also in the series of lakes whose drainage unites to form the Faun River. The largest lake in one series is James Lake, and in the other is Crooked Lake. Approximately a mile apart they lie, but with a difference in elevation of 23.5 feet (Tucker, 1922, p. 400). The average carbonates for Crooked Lake is 26.37 while that for James is 38.00.

The James series, with their carbonates, consist of Marsh 48.95, Upper Otter 47.45, Lower Otter 41.02, Snow 41.00, James 38.00, Jimerson 36.67.

The Crooked Lake series follows: Center 31.92, Loon 24.96, Crooked 26.37, Gage 30.22. The arithmetical average for the perched lakes, i. e., the Crooked Lake series, is 28.36, while that for the lower lake series is 42.18.

The "softening" of lakes by photosynthesis is the result of the following well known facts. The carbonates in solution in lake water are in the form of the bicarbonate. In photosynthesis the plants not only use the free carbon dioxide in solution, but are also able to use the second radical of the bicarbonate, the so-called "half bound" carbon dioxide. This leaves the normal carbonate which is precipitated as "marl."

In a series of lakes whose difference in level is slight and which are connected by streams of considerable volume, the amount of carbonate in solution is gradually reduced. This is best illustrated in the series Marsh, Upper Otter, Lower Otter, Snow, James, and Jimerson Lakes cited above.

In other instances variations in leaching caused by variation in the differential between the lake level and the level of the surrounding moraines overbalance the effect of photosynthesis. In the series of lakes which is tributary to the Pigeon River, Pleasant Lake is little below the level of the surrounding land while farther down lies Golden and Hogback surrounded by high moraines. The former has 27.15 cc. carbonates while the latter have 54.73 and 44.49, respectively. Golden is the highest in carbonates of any lake examined in this study.

Lake	Depth	T		O2		CO_2 Free		Cb	
	Surface and Bottom								
1. Center.......	5.	23.7	18.9	3.57	0	0	6.97	30.37	33.86
	5.	25.	24.4	5.38	0	.74	5.68	30.15	32.12
2. Clear.........	32.50	22.2	10.4	5.71	.08	− .99	5.72	24.40	28.18
	30.	24.2	10.2	6.41	1.58	−1.23	4.94	24.96	27.18
3. Crooked......	21.	26.7	10.6	5.91	0	0	7.85	22.93	28.79
	23.	22.2	10.4	5.5	.8	0	1.5	24.63	28.11
4. Fox..........	17.5	24.4	10.8	6.2	0	−1.22	5.13	26.42	33.02
5. Golden.......	9.5	26.1	11.7	5.15	0	3.19	18.45	46.00	63.46
6. Gage.........	21.	24.4	10.6	5.31	0	0	8.46	26.64	39.59
	21.5	22.2	10.6	5.9	0	−.99	5.47	28.86	31.39
7. George.......	25.	25.6	11.1	6.23	.1	0	6.47	27.63	34.86
	25.	23.3	11.1	5.7	.9	0	5.47	30.60	33.09
8. Hamilton(Fish)	19.	27.2	11.7	6.56	0	− .73	7.32	24.40	29.03
	19.	24.4	11.7	7.2	.05	−1.23	9.63	26.44	30.39
9. Hog.........	9.	26.6	13.3	6.09	.34	0	−7.03	27.92	36.54
10. Hogback.....	5.5	24.4	15.6	6.03	0	0	17.25	40.86	58.21
	8.	24.4	13.9	5.05	0	0	16.79	40.17	48.12
11. Jimerson.....	17.	24.4	10.	5.57	.06	0	5.68	33.61	39.54
12. Lake Pleasant.	10.	25.6	14.4	5.57	.21	0	4.54	24.97	28.60
13. Long.......	9.5	24.4	12.2	5.33	0	.6	5.74	47.72	57.07
14. Loon.........	4.	26.7	21.4	4.76	1.99	.98	3.93	24.10	25.83
15. Marsh........	11.	25.6	10.	6.73	.10	0	9.27	50.75	44.16
16. (Lower) Otter.	12.	24.8	10.	5.89	.11	0	6.92	42.01	40.03
17. (Upper) Otter.	10.	25.6	10.6	6.20	.07	0	6.40	50.66	41.27
18. Pleasant Lake.	13.	25.9	11.7	5.7	.67	0	5.13	24.40	29.84
19. Silver........	11.	25.	11.7	5.00	.10	0	8.17	26.33	36.09

Depth 30+ Clear

20-29 Crooked, Gage, George.

10-19 Fox, Hamilton, Jimerson, L. Pleasant, L. Otter, U. Otter, Pleasant Lake, Silver.

10 Center, Golden, Hog, Hogback, Loon.

TABLE No. 2. Summary table for the lakes of Steuben County.

Birge and Juday (1911, p. 136) have shown that extremely soft water lakes such as those of northeastern Wisconsin are relatively poor in plankton especially phytoplankton. The above mentioned authors divide the lakes of Wisconsin into three classes with reference to carbonates, namely, soft, medium, and hard. The soft water lakes contain carbondioxide as carbonate in amounts less than 5 cc. per liter, the medium 5 cc. to 22 cc. per liter, and the hard water lakes above 22 cc. per liter. On this basis, all lakes considered in this paper are hard water lakes varying in carbonates from 24.96 cc. per liter to 54.73.

Theoretically the amount of phytoplankton should be roughly proportional to the amount of carbonates. Plant growth is also dependent upon other factors. The form of the basin is a potent factor. The shallower lakes generally produce more phytoplankton than the deeper lakes. For example, Hogback Lake with a depth of 8.5 meters has more phytoplankton than any other lake of the series, while Clear Lake of Steuben County, with a depth of 32 meters, is relatively low in phytoplankton.

Rice (1916) and others have shown that the amount and nature of nitrogen compounds are related to plant growth in water. Atkins (1924) has shown a similar relation for phosphorous. Allen (1914) finds some unknown organic compound necessary for the artificial culture of marine plankton.

In spite of these and other factors known to influence plant growth, it appeared probable from the inspection of our data that the number of certain diatoms was correlated with the amount of carbonates.

The average amount of carbonates in thirty-two lakes was determined by taking the arithmetical average of the maximum and minimum. (The volume of most of the lakes is unknown, so that the amount of the carbonates could not be more closely determined.) The coefficient of correlation between this average of the carbonates and the number of three phytoplanktons Fragillaria, Melosira, and Clathrocystis was .4549, .4559, and .0284, respectively.

It appears from this that in spite of other factors influencing plant growth, there is a significant correlation between the carbonates and diatoms, but not between carbonates and blue green algae. Correlations above .3 are usually regarded as significant. These diatom correlation factors are nearer .5 than .4.

OXYGEN

In discussing the distribution of oxygen, it is necessary to recall the thermal stratification during the summer of lakes in temperate latitudes. Due chiefly to thermal resistance to mixture, lakes become stratified during the warmer months into a warm upper layer, beneath which is a stratum whose temperature decreases rapidly as the depth increases, and below this is a region of relatively cold water. These are known respectively as the epilimnion thermocline (mesolimnion) and the hypolimnion. In these lakes the epilimnion is usually five or six meters thick. The thermocline extends from a depth of five or six meters to a depth of ten to twelve meters. The hypolimnion occupies the depth beyond ten or twelve meters. This stratification is usually established by the first of June and lasts until the middle of October in the shallower lakes, and about a month longer in the deeper lakes.

In addition to the thermal stratification of lakes, the amount of oxygen is influenced in the upper levels by photosynthesis which in turn is determined by the amount of incident solar energy and the depth to which the various wave lengths penetrate. The amount of incident energy at the equinox when the sun is at meridian varies with cosine of the latitude. This amount varies diurnally toward zero at sunrise and sunset. The long days of summer at high latitudes tend to offset the influence of the lower angle of incidence.

Birge and Juday (1921) using a thermocouple (bolometer) report that 5% of the sun's energy remains at 5 meters and about 1% at 10 meters. More refined results and very elaborate data are given in a later paper (Birge and Juday, 1929). In sea water Shelford and Gail (1922), using a photoelectric cell, found that about 10% of the light penetrating the surface remained at 10 meters. Klug (1925) using an instrument based on photographic emulsion found that 27% of the light which penetrated the surface remained at 5 meters and that 1.5% persisted at 10 meters. Shelford found 25% of the incident light reflected, Klug 33%.

From the above results it is evident that in our lakes whose transparency approximates that of the Wisconsin lakes, the epilimnion is well lighted and the thermocline receives light sufficient for photosynthesis especially in the upper half. In practically all our lakes the hypolimnion lies below 10 meters. From the results of Birge and Juday l. c. the hypolimnion never receives as much as one per cent of the incident solar energy.

The Hypolimnion

The hypolimnion is completely sealed from the air during the period of summer stagnation. It is cold and dark. This means that all the oxygen it has is that taken down with the water during the vernal circulation. This amount is gradually reduced. This reduction is due in part to the respiration of the organisms present, but usually the most important factor in its reduction is the decay of organic matter. There is always organic matter on the bottom of the lake. Its decay reduces the oxygen in a thin stratum of water in contact with it.

However, the organisms that live at and near the surface (in the epilimnion) die in large numbers and their remains slowly sink. As they pass through the lower strata of water, they slowly reduce the amount of oxygen. It is obvious that the rate of oxygen reduction depends on two factors, the amount of this organic matter present and the temperature of the water. The temperature of the water depends on the date of stratification. Some lakes stratify earlier than others and the same lake may stratify at different dates in different years.

Of the thirty-two lakes (excluding James and Snow), twelve had no oxygen at the bottom on the date examined. Seventeen others had less than 1 cc. per liter. Of the three that had an excess of 1 cc. per liter, two (Clear of Steuben and Crooked of Whitley County), are the deepest of the series, 32 and 30 meters respectively. Crooked of Whitley is cold on the bottom; its temperature, 6.1° C., is equaled only by Cedar of Whitley. Clear is moderately cold, 10.7° C., but is usually rather free from organic matter. Its littoral is especially free from plants. These two factors account for the persistence to mid-summer of considerable oxygen at the bottom.

Loon Lake on the other hand is the shallowest lake in the series. Its depth is only four meters. On the day the collection was made its surface temperature was 26.7 while the bottom was 21.4.

The temperatures clearly indicate that the lake is mixed to the bottom by the wind during the summer. A period of calm weather would rapidly reduce the oxygen in the lower layers because of the high temperature.

Lake	Date	S	2	4	6	8
1. James N	6–19	104	104	105	103	
2. James J	6–20	108	104	106	102	
3. James L	6–21	105	104	107	101	
4. James B	6–21	103	104	103		
5. Snow	6–22			100.7		
6. Snow	6–22			100.4		
7. James A	6–24	113	111	121	108	
8. James J	6 24	112	110	116	108	
9. James D	6–25	109	107	113	103	
10. James F	6–25		107	113	102	
11. James I	6–26	106	108	116	110	
12. James H	6–27	106	104			
13. James K	6–28		108	109	106	
14. James C	7–1	115	118	115	107	
15. James E	7–2	116	116	110	116	
16. James U	7–2			114	104	
20. James M	7–4			101		
22. Gage	7–6					158
23. Fox	7–10	106	106	102	123	
26. Hamilton	7–11	122	122	105		
27. Center	7–14		101			
28. Clear	7–15	107	107	110	107	139
29. U. Otter	7–17	108				
30. L. Otter	7–18	106	106			
32. Hog	7–23	106	102			
34. Silver	7–24			100		
35. Hogback	7–24	103				
39. Crooked	7–30	103	103	103		
40. Hamilton	7–31	106	115	103		
41. Marsh	8–1	115	112			
42. George	8–2	108	111	105		
44. Gage	8–3					153
45. Clear	8–5					134
50. James G	8–8	100	102			
51 James I	8–9	102	101	104		

TABLE No. 3. Oxygen supersaturations for the year 1929. All except those at 8 meters are in the epilimnion.

The Thermocline (mesolimnion)

The thermocline like the lower levels of the lake (hypolimnion) is sealed from the atmosphere during the period of stagnation but unlike the hypolimnion its temperature varies from that of the epilimnion above to that of the hypolimnion below. It often receives an appreciable amount of light. Its temperature facilitates both more rapid decay of organic material and more

rapid metabolism in the living organism than occurs in the cooler waters beneath it.

The result is that when few chlorophyl bearing organisms are present the oxygen is often reduced more in the thermocline than it is in the upper part of the hypolimnion. This produces what might be called the thermoclinal oxygen notch. It regularly develops in Tippecanoe Lake. In these studies I have found it in station N of James Lake, and in Station O in Snow Lake.

Birge and Juday (1911) report it for lakes North, Green, and Knights. Litynske (1926) found it in Lake Wigvy. Lake Plön and "Schöhsee" according to Thienemann (1928) develop this condition.

This deficiency of oxygen in the thermocline is always subsequent to the establishment of the summer stratification. It usually develops in August and lasts into September. The earliest recorded date I have been able to find is July 12 in Plön, Thienemann (l. c., p. 168). However, in this instance the amount at 15 meters is only .56 cc. per liter less than the amount at 20 meters.

The biological significance of this will be discussed in its relation to the cisco (Argyrosomus artedi cisco Jordan).

Occasionally a rather dense flora of diatom or algae develops in the thermocline. When this occurs the water may become highly super-saturated. A super-saturation in the thermocline is much more permanent than one developed in the epilimnion because the water of the thermocline is not exposed to the air.

For instance, a super-saturation was found in Otter Lake in 1909 at 4 meters on July 2. This was still present on July 17 and August 13 (Birge and Juday, 1911, Figures 59, 60, 61).

In these lakes Gage had a super-saturation of 158% at 8 M. on July 6. On this date the 5 to 10 meter level had 74,135 Lyngbya per liter. On August 3 the saturation at 8 meters was 153% although the amount of phytoplankton had declined. In Clear Lake the saturation on July 15 was 139% and on August 5 it was 134%. The super-saturation that develops in the thermocline may persist more than a month and for a considerable period after the decline of the plankton flora that produced it as the data in Gage indicated.

In general the oxygen in the thermocline may reach a minimum as low as that of the hypolimnion or it may have a maximum exceeding that of the epilimnion. In either case the condition is very persistent usually lasting until the sinking of the thermocline restores the circulation of the water with that of the epilimnion.

	June	July	August
1929:			
Hours	354.3	368.3	299.9
Mean percent	78.	80.	70.
Normal percent	67.	70.	66.
1930:			
Hours	332.9	351.7	215.1
Mean percent	74.	77.	50.
Normal percent	67.	71.	66.
Excess Hours 1929 over 1930	21.4	16.6	84.8

TABLE No. 4. Sunshine records from the monthly meterological summary, Ft. Wayne station.

Epilimnion

Oxygen in the epilimnion may change rapidly but rarely does the amount become excessively high or low. This region is influenced by the vicissitudes of the weather as well as the diurnal changes. When considerable phytoplankton is present a calm clear day will result in a super-saturation of oxygen. But a high wind will reduce this to about the saturation point.

Theoretically there should be a diurnal oxygen pulse in the epilimnion on clear days. This is, however, rarely detectable. Birge and Juday (1911, p. 43) found it in Mendota on September 21, 1908. It was demonstrated (Scott, 1923) on Winona Lake August 9, 1922. On Winona Lake it has been impossible to demonstrate this pulse except in very calm and clear weather.

However, even with slight breezes a super-saturation may be built up if there are successive days of sunshine. In 1929 there were 51 series of O_2 determination. In these 51 series there were 32 super-saturations in the epilimnion or 62% of the series. In 1930 there were 7 super-saturations in 24 series or 29% of the total.

An increase of the oxygen above the saturation point in the epilimnion can only be accomplished by photosynthesis. This in turn depends on the number of phytoplanktonts and the number of hours of sunshine. The number of phytoplanktonts varied from lake to lake, but there was no appreciable difference between the two years.

The sunshine records were obtained from Fort Wayne. The U. S. Weather Bureau Station at Fort Wayne is the nearest station to this group of lakes. The lakes average about 40 miles from Fort Wayne. They are arranged roughly in an arc from north to north of west.

These data appear in Table No. 3. There was more sunlight in each of the summer months in 1929 than there was in 1930. In 1929 this excess amounted to 21.4 hours, 16.6 hours, and 84.8 hours in June, July, and August. In 1930 most of our work was done in August, the month of the greatest excess. The normal percent of sunshine for August is 66. The mean for August, 1930, was 50 while the mean for August, 1929, was 70. That is, there was approximately 40% more hours of sunlight at Fort Wayne in August, 1929, than there was in 1930.

There is evidence that records obtained at a station in the middle of a city differ from those taken in the open country. There is no evidence that this relation would vary from year to year.

The above data indicate something of the amplitude of seasonal variation in the epilimnion. How much this seasonal variation in photosynthesis and the consequent production of carbohydrates would affect the other life in the lake is unknown. It has been shown (Hjort, 1914 and others) that some marine fishes grow more rapidly one year than another. So far as I know this has not been clearly demonstrated for fresh water fish.

THE PLANKTON

The plankton is one of the most important elements in the economy of a lake and one of the most difficult to evaluate. It has been measured volumetrically, numerically, and gravimetrically. The volumetric and gravimetric methods are relatively rapid, but neither permits analysis of the components of the plankton. Plankton is studied as a mass and not as an association of organisms. The volumetric method also has the well known difficulty arising from the fact that different planktonts settle or centrifuge at different rates.

By enumerating the different organisms it is possible to compare their relative abundance in different lakes and to determine their seasonal variations. The difficulty of this method is that neither the weight nor volume of any individual organism of the plankton is accurately known so that the weight or volume of plankton per unit cannot be calculated.

Another difficulty in evaluating plankton is that a few of the forms are probably end products, while many of them are not. The crustacea, especially the cladocera, eat the smaller phytoplankton and in turn are eaten by the fish. The number or amount present at a given time are those that have *not* been eaten or destroyed in some other way. The value of any organism is not a function of the number present at a given moment, but is a function of the reproductive capacity of this population.

Lake	Number Daphnids sq. M. Max. Depth	Food Available for Number gms. of Fish sq. M.	Pounds of Fish Per Acre Possible
Golden	150,000	1,442	12,872
Hogback	209,000	2,009	17,811
Long	246,000	2,365	21,049
George	52,000	500	4,452
Clear	36,000	346	3,076

TABLE No. 5. The number of units of fish that the summer daphnid population will support. The first three lakes are especially rich in daphnids and are probably out of balance. The last two are poorer in daphnids and are probably more nearly balanced.

Banta (1921) reared Daphnia in an unbroken line from April, 1912, until September, 1916, nearly four and one-half years. He determined a reproductive factor by dividing the number of young in a brood by the time between broods. In the "minus" line, the reproductive factor was .99 and in his plus line it was 1.08. This means that on the average each parthenogenic adult produced approximately one young per day. If a population remains constant, an amount equally this population will be produced and eaten daily.

While it is not possible to convert any number of Daphnia into gravimetric or volumetric units, it is possible to convert these numbers into fish food requirements by experimental methods. This work was begun by Miss Blanche E. Penrod. By direct observation in an aquarium, she was able to determine the number of daphnids eaten by a blue gill in a given period of time; these periods varied from 15 minutes to one hour. The counts were recorded by a "tallying machine." The work is to be continued, but the results already obtained help in the interpretation of the plankton counts.

In 39 series, blue gills, each weighing 16 grams, ate on an average 139 daphnids per hour. We do not know just how many hours per day a blue gill feeds. If we assume that it feeds for 12 hours a blue gill weighing 16 grams would consume 1668 daphnids, or 104 daphnids per gram of fish.

If this amount is divided into the number of daphnids present in a given column of water (which equals its productive capacity), the quotient represents the number of grams of fish that the daphnids present on that date would support.

In Table 4, this has been computed. Golden, Long, and Hogback Lakes are shallow, rich lakes. George and Clear are relatively deep lakes, not

subject to such rapid changes in temperatures and biota as occur in the shallower lakes. The seasonal changes in daphnid populations are extreme. Especially is this true in shallow, rich lakes. The maxima occur during the spring, summer, or fall, when the fish feed most. The evidence from hatchery plants and from scale studies indicates that fish in inland waters feed little during the colder parts of the year. However, it is hardly likely that a lake would support a fish population indicated by the maximum daphnid population. The average for the warmer months would be a better basis for estimation.

It is also true that blue gills at times feed almost wholly on other organisms. In Wawasee Lake, Hile found them feeding at times almost wholly on chironomid larvae. When the seasonal variations in feeding are worked out, it may be that during daphnid minima, other foods make up the deficit. These questions must await further data.

Another bit of evidence that assists in this evaluation is some data on the contents of fish stomachs. During the studies of Dr. Hile on the fish scales, Mr. E. G. Thomas determined the contents of the stomachs of 412 fish of which 292 were blue gills. Of these blue gills, 138 had eaten daphnids. The work had to be done rapidly. The contents were fractionated and an aliquot part of the daphnids counted. Absolute accuracy was not attained but the results are a fair approximation. Some of the fish contained more daphnids than others. The average number per gram of fish for the 138 fish was 5.5. The maximum for a single fish was 26 daphnids per gram. This indicates that the estimate that daphnids may feed 12 hours per day is too high and consequently the estimate of the number of pounds of fish a lake will support is too low.

The food of the daphnids consists of the smaller forms in the plankton, the so-called nannoplankton. The amount of this that a daphnid requires is a rather difficult problem. The volume of the alimentary canal of Bosmina, Daphnia pulex and Daphnia retrocurva has been determined by making a model to scale and measuring this volume by water displacement. The volumes are .00109 cc., .00287 cc., and .00336 cc., respectively. Some data have been collected on the rate at which food passes through the alimentary tract of these forms. Although 144 readings have been made, some of the results are rather erratic. Consequently, they are withheld until the factors causing the variations are determined. It is hoped that this work will add one more link in the "food chains" in our lakes.

JAMES LAKE—ITS PECULIARITIES

James Lake has the most complex basin of any lake whose map or description I have been able to secure. It has three major basins designated first, second, and third, beginning at the south. Snow Lake, lying to the north of the third basin, is really a fourth basin of Lake James, although the channel connecting the third basin and Snow Lake is longer, narrower, and shallower than the channels connecting the other basins. These four basins lie in a great crescent with the convex side to the west (see map). The first and second basins are connected by a channel 800 feet (242 M.) wide and 27 feet (8.2 M.) deep. The channel connecting the second and third basin is 500 feet (152 M.) wide and 30 feet (9.1 M.) deep.

These four primary basins have twenty-one secondary basins or deeps distributed as follows. The first basin has eight, the second five, the third three, the fourth (Snow) five. These secondary basins differ from each other physically, chemically, and biologically. In Table 6 I have selected five pairs that have the same depth. The bottom temperatures of the basins having the same depth differ from .5 degrees C. in basins N and O to 2.8 degrees in basins E and K. This indicates that the basins stratify on different dates. Those with the colder water at the same depth stratify first.

Two factors influence the rate at which oxygen is depleted from the bottom. The higher the temperature and the more organic matter present, the more rapidly the oxygen is reduced. In the pairs CU, BJ, and NO, the temperature is the more potent factor. In the basins GP and EK, the oxygen is lowest at the bottom in the basin of each pair that has the lowest temperature indicating that more organic matter or more easily oxidized material is present in the basin with the minimum temperature.

Date	Station	D	T	O	CO_2	Cb
6–24	G	15	13.1	3.1	3.8	35.78
7–4	P	15	10.6	0	7.50	38.42
7–2	E	17	12.8	2.7	2.84	38.28
6–28	K	17	10.	1.3	7.52	31.82
7–1	C	18	11.7	1.5	4.90	39.30
7-2	U	18	10.0	4.1	4.12	38.78
6–21	B	20	11.7	2.0	1.38	39.18
6–21	J	20	9.2	2.6	1.64	38.42
6–19	N	25	6.7	2.3	3.52	38.92
6–22	O	25	7.2	0	7.70	42.42

TABLE 6. Comparison of Stations of the same depth in James Lake.

PLANKTON

Species	Sta.	0–5	5–10	10–15	15–20
Ceratium	N	2,448	332	284	11
	B	1,105	298	76	93
Dinobryum	N	19,051	288	136	21
	B	3,357	439	149	51
Daphnia	N	4.5	6	4	6
	B	8.	8.8	8.8	12.8
Holopedium	N	113	. .	. .	. . . . . .
	B	0	. .	. . .	. . . .
Diaptomus	N	12	84	0	4
	B	8.8	4.8	14.4	10.4
Cyclops	N	13	64	. .	5
	B	21.6	3.2	7.2	5.6
Nauplii	N	19	64		4
	B	42	29	4	29.6
Melosira	N	7,597		231	217
	B	422	51	119	294
Fragillaria	N	9,525	5,040	1,752	1,203
	B	849	772	1,186	2,709
Clathrocyctis	N	11,680	204	. .	.
	B	1,809	430	221	264

DISSOLVED GASES

D		T	O	%	CO	Cb
S	N	24.4	6.1	104	0	19.98
	B	24.2	6.0	103	25	18.70
20	N	7.3	4.8		1.76	19.46
	B	2.	2.0		.69	19.59

N—Depth 25 M.—date 6-19-29
B—Depth 20 M.—date 6-21-29

TABLE No. 7. Comparison of Stations N and B James Lake.

LAKE: JAMES, STATIONS E AND U
Date: 7-2-1929—Aug. 1-18 M.

PLANKTON

Species	E	U
Ceratium	1,194	610
Dinobryum	8	74
Aneura	52	35
Polyarthra	13	11
Notholca	20	9
Daphnia	1.7	3.7
Diaptomus	18	14
Cyclops	19	13
Nauplii	19	13
Melosira	210	158
Fragillaria	4,222	3,011
Asterionella	722	389
Anabena	4	..
Clathrocyctis	56	37
Lyngbya	194	483

DISSOLVED GASES

D	Temperature		Oxygen	
	E	U	E	U
S	22.2	22.1	7.1	..
2	22.2	21.7	7.0	....
4	22.2	21.1	7.1	7.1
6	18.9	16.4	7.0	7.07
8	14.7	13.9	6.8	6.7
10	13.7	12.8	5.7	6.2
12	13.3	11.1	4.3	5.5
15	13.1	10.2	3.7	4.3
17	12.8	10.	2.7	4.1

TABLE 8. Comparison of collections taken at stations of the same depth on the same date.

Not only do these basins differ in temperature and the distribution of gases, but the planton is different. In Table 7 Stations N and B are compared. From the bottom temperatures, it is evident that Station N stratified later than Station B. Correlaed with this is a much richer plankton in the former than in the latter. At Station N, Ceratium, Dinobryum, Melosira, Fragillaria, and Clathrocystus are strikingly more numerous than at Station B.

There are 113 Holopedium per liter at N, while it is entirely absent from Station B.

There are two days difference in the dates of the collections at these two stations.

The collections at Stations E and U were made on August 18. The differences here are quite apparent.

Ceratium, the rotifers, and all the phytoplankton were more numerous at E than U, while the reverse was true of Dinobryum and Daphnia.

In this case, as in Stations B and N, the station that had stratified later as indicated by the higher bottom temperature had developed the more plankton.

The epilimnion beyond the littoral is usually regarded as a rather homogeneous association. It appears from these data that it is homogeneous only because the thermocline and hypolimnion beneath it are homogeneous. Where these lower depths are separated by barriers they develop different characteristics. They differ in temperature, in oxygen, in carbonates, and probably in organic matter.

It seems apparent that the lower levels of a lake have a much more intimate relation and direct influence on the epilimnion during the summer stratification than has heretofore been suspected.

I first noted differences in temperature and dissolved gases in the different secondary basin of Webster Lake (Scott, 1916, p. 17). Welch (1927) has noted marked differences in the physical and chemical characteristics of the seven secondary basins of Douglas Lake.

The next problem is the analysis of the biological peculiarities of each basin and their relation to the physical and chemical characteristics of the basin. What influence one basin may have on another is entirely unknown.

RELATION OF DISSOLVED OXYGEN AND CISCO

Early in September, usually between the first and tenth, the "cisco" (Argyrosomus artedi cisco Jordan) come to the surface of Snow Lake, struggle as if in discomfort, and then disappear. They have been described by local observers as "gasping for breath." When they begin to appear a maximum is soon reached, after which the number at the surface is rapidly reduced. The maximum rarely lasts more than a day and the whole phenomenon is over in less than a week. This has been observed on Snow Lake for at least thirty years. It occurs occasionally on the third basin of James Lake.

They have been examined repeatedly for parasites without success.

I suspected that the disappearance of the oxygen from the hypolimnion might be the cause.

In the fall of 1928 cisco were taken from Indian Village Lake, a small lake about four miles southeast of Lake Wawasee (Turkey Lake). A preliminary set of soundings indicated that its maximum depth was near six meters. It was possible that cisco taken in Indian Village Lake in November during the breeding "run" might have come from lakes farther up the chain. There are six lakes in the so-called Indian Village chain.

In 1929 a map was made of Indian Village Lake and the oxygen, carbonates, and temperature determined. The maximum depth was 6.4 meters. Only a trace of oxygen was found below 4 meters. Dr. Ralph Hile then set a 12 foot gill net in the deeper part of the lake, and took fish in the upper 2 feet only of the net.

The fish never appear at the surface except at the breeding "run" in November.

Tippecanoe Lake develops an oxygen "notch" in the thermocline, but the oxygen in the hypolimnion is rarely, if ever, reduced to a level dangerous to the "cisco."

The evidence from Indian Village Lake indicates that the mere disappearance of the oxygen from the hypolimnion causes no discomfort if the oxygen curve maintains a simple sigmoid form. The development of a thermoclinal notch in the oxygen curve is not in itself dangerous. However, if there is a thermoclinal notch developed in the oxygen curve and subsequently the oxygen is exhaused from the lower hypolimnion, the fish will be forced upward by the latter process until they reach the lower part of the thermocline. From this level they move into a region of less oxygen by going either up or down. They are trapped and remain at this level until they approach asphyxia. When they lose control of their hydrostatic apparatus, they float

toward the surface. When this occurs in Snow Lake, they have 3 meters above them with little or no oxygen. This increases their discomfort. Although there is much oxygen in the upper 7 meters the fish float to the surface before they make a complete recovery.

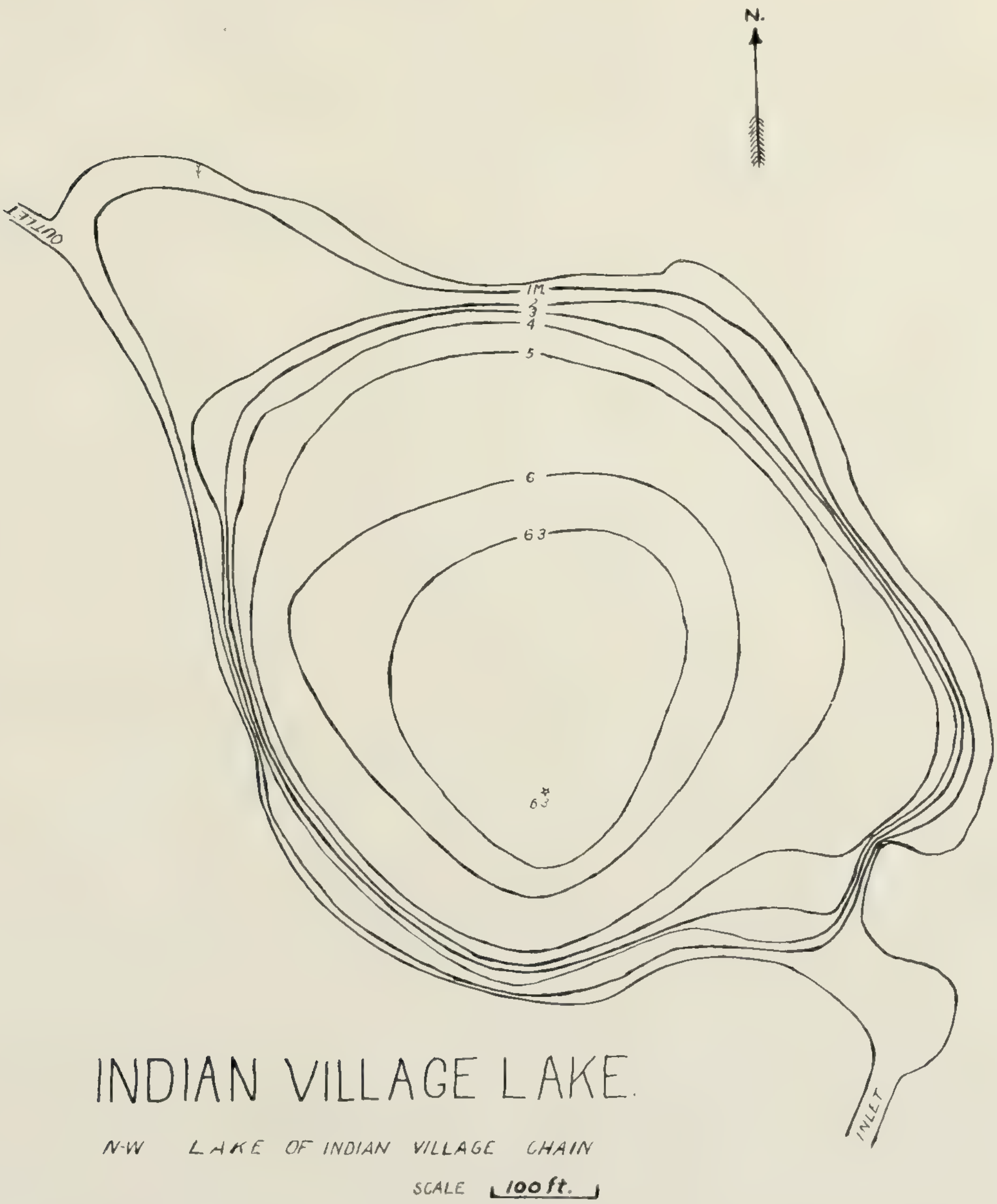

FIG. 2.

In Figure 3, the curve for Tippecanoe Lake has an oxygen notch with plenty of oxygen remaining in the hypolimnion. The curve for Indian Village Lake is a simple sigmoid curve. The curve for Snow Lake dated 9-7-30 shows the notch developed. In the curve for 9-14-29, the water is near oxygen saturation for the first 7 meters. At 8 meters there is approximately one-half as

much as at 7. At 9, 10, and 11 meters there is no oxygen but at 12 meters it appears again. This is the point just below the thermoclinal notch. So far high winds have prevented quantitative collections to demonstrate the accumulation of fish just below the thermoclinal notch. After they disappear from the surface they remain in the epilimnion. This has been demonstrated by netting. The other facts connected with this suggestion are well established.

For many years the fish have been gathered with dipnets in Snow Lake during the time when they come to the surface. With hand propelled craft they seem to have held their own. However, the increased us of the outboard motor has resulted in nearly every fish that reaches the surface during daylight hours being captured. The catch in 1929 and in 1930 is reported to be much below the normal. *The present regulation* should probably be modified in order that *sufficient stock be preserved for breeding.*

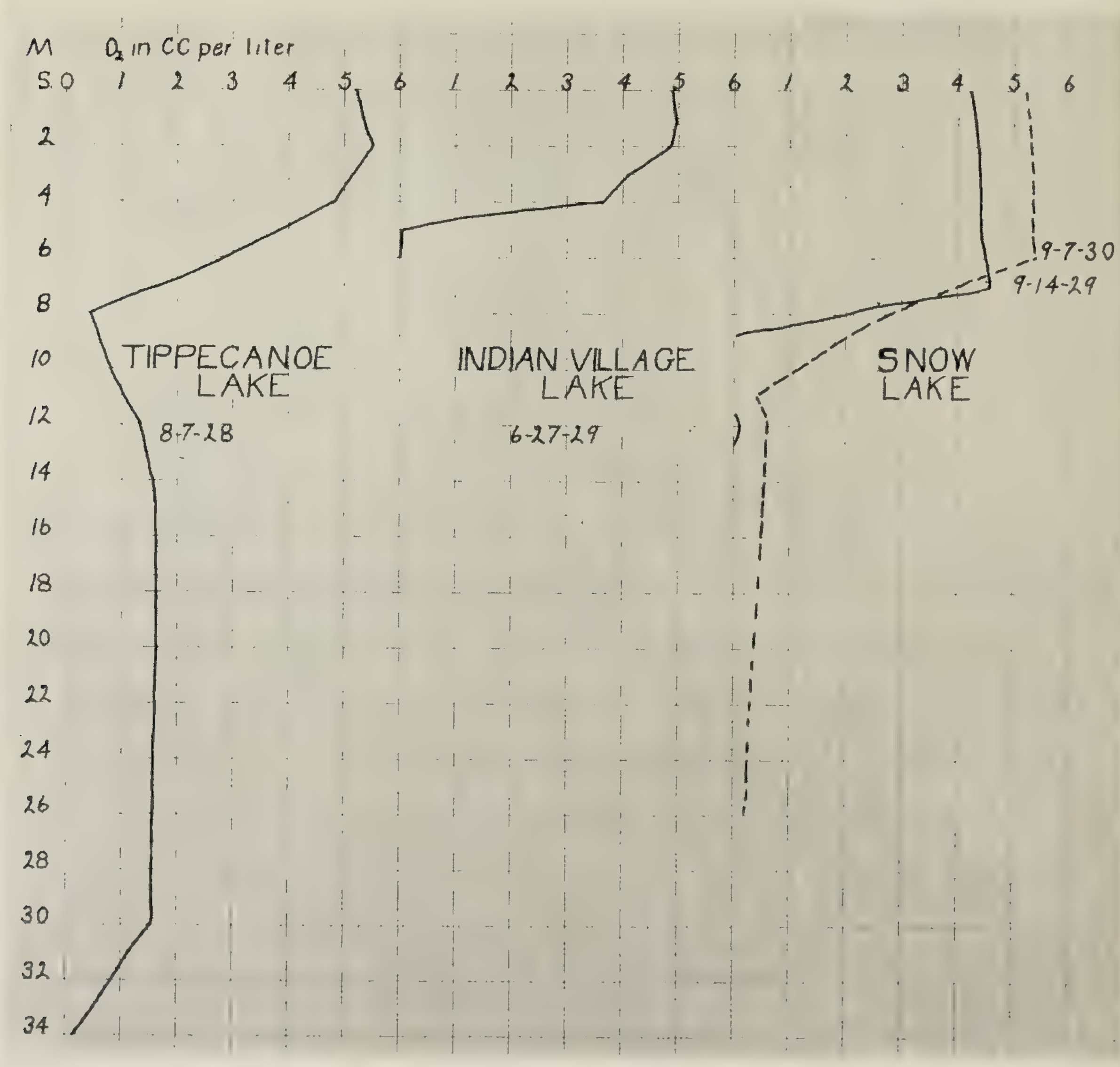

FIG. 3. Oxygen curves for Tippecanoe, Indian Village, and Snow Lakes.

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EXPLANATION OF TABLES

The figures 0-5, 5-10, 10-15, and 15-20 are depth in meters.
D—Depth. T—Temperature. O—Oxygen. %—Percent of saturation. CO_2—Carbon-dioxide. Cb—Carbonates.

TABLE 9.
LAKE: ADAMS (LaGrange)
Date: 9/6/30

Plankton					Dissolved Gases						
Species	0-5	5-10	10-15	15-20	D	T	O	%	CO_2	Cb	pH
Ceratium	519	110	17	4	S	22.7	6.52	100	—1.4	25.4	8.3
Dinobryum		4			2	22.4	5.48		—1.6	25.8	
Aneura	59	21	4	8	4	22.3	5.27		—2.2	26.2	
Polyarthra	12	4			6	21.1	4.41		-1.0	26.0	
Asplancna				4							
Noltholca			.8		8	13.	.12		1.4	33.0	
Daphnia	4.8	.8	3.2		10	10.3	.17		1.6	33.2	
					12	9.7	.07		1.6	32 0	
					15	8.9	.06		1.4	32 4	
Diaptomus	13.6	3.2	1.6								
Cyclops	20.8	10.4	2.4	1.6							
Nauplii	12.8	10.4			20	8.8	0		2	32.8	
Corethra		.8									
Melosira	115	46	17	4	25	8.8	0		3.2	33.0	
Fragillaria	554	64	81	21							
Asterionella											
Anabena	353	76	4	4							
Clathrocyctis	2,197	806	174	307							
Oscillatoria	1,216	401	123	128							
Lyngbya	12										

TABLE 10.

LAKE: BIG CEDAR (LaGrange)
Date: 9/2/30

Species	0-5	5-8	10-15	15-20	D	T	O	%	CO_2	Cb	pH
	Plankton				Dissolved Gases						
Ceratium	1,055	307			S	24.4	5.33		-1.4	31.6	8.3
Dinobryum	465	128			2	24.4	5.88	101	—2.4	31.8	8.2
Aneura	64	64			4	23.8	5.93	191	—2.0	32.4	8.1
Polyarthra	17				6	22.0	2.75		0	33.4	7.6
Noltholca	4.2				8	21.1	.12		0	34.8	7.5
Daphnia	1.6	10									
Ostracoda		8.8									
Diaptomus	20	12									
Cyclops	28	6.4									
Nauplii	30	11.2									
Melosira	8	4									
Fragillaria	3,878	2,235									
Asterionella	4										
Anabena	46										
Clathrocyctis	2,073	1,024									
Oscillatoria	21	21									
Lyngbya											

TABLE 11.

LAKE: BIG CEDAR (Whitley)
Date: 8/12/30

Plankton

Species	0-5	5-10	10-15	15-20
Ceratium......	4.2	8.5		12.8
Dinobryum....		4.2		
Aneura..........				
Noltholca		12.8	4.2	
Polyarthra				
Asplancna	8.5	4.2		
Hexarthra	4.2		8.5	12.8
Daphnia	2.4	10.4	15	28.8
Diaptomus	5.6	16	.8	
Cyclops	3.2	14.4	14.4	11.2
Nauplii	17	46.9	76	81
Corethra		21	4.2	
Melosira		4.2		
Fragillaria	25	25	64	110
Asterionella		12.8	59	42
Anabena	68	136	29	29
Clathrocyctis	21	298	89	153
Oscillatoria		8.5	4	
Lyngbya	12.7	119	21	12

Dissolved Gases

D	T	O	%	CO_2	Cb
S	26.1	5.38		—1.4	28.8
2	25	5.35		—1.4	29.2
4	24.4	5.69		—1.0	28.2
6	17.7	6.71		1.4	29.2
8	13.3	7.10		—1.4	31.8
10	10.3	5.97		—1.0	31.8
12	8.8	4.57		.4	32.0
14	7.2	2.90		2.0	31.6
21.5	6.1	40		2.0	31.6

TABLE 12.

LAKE: CENTER
Date: 7/14/29

Species	Plankton 0-5	5-10	10-15	15-20	Dissolved Gases D	T	O	%	CO_2	Cb
Ceratium	29				S	25	5.48		-.74	30.14
Dinobryum					2	25	5.85	101	—.74	29.90
Aneura	145				4	24.7	.55		4.20	31.14
					5	24.4	0		5.78	32.12
Polyarthra										
Asplancna	42									
Hexarthra	12									
Daphnia										
Bosmina	72									
Ostracod	.8									
Diaptomus										
Cyclops	96									
Nauplii	72									
Corethra	.8									
Melosira	768									
Fragillaria	68									
Tabellaria	12									
Asterionella										
Anabena	51									
Clathrocyctis	1,211									
Oscillatoria	665									
Lyngbya	1,715									

TABLE 13.

LAKE: CENTER
Date: 8/3/29

Plankton						Dissolved Gases					
Species	0-5	5-10	10-15	15-20		D	T	O	%	CO_2	Cb
Ceratium	196					S	23.3	3.85		0	30.36
						1	23.3	3.79		0	31.36
Dinobryum	435					2	23.3	3.74		0	30.12
						3	22.8	4.05		0	30.36
Aneura	64					4	20.3	0		5.18	31.62
Hexarthra	106					5	18.9	0		6.96	33.96
Polyarthra											
Noltholca	4										
Asplancna	119										
Daphnia	2.4										
Bosmina	110										
Ostracod	8.8										
Diaptomus	2.4										
Cyclops	208										
Nauplii	123										
Melosira	580										
Fragillaria	537										
Asterionella	17										
Anabena	38										
Clathrocyctis	1,111										
Oscillatoria	533										
Lyngbya											

TABLE 14.

LAKE: CROOKED (Steuben)
Date: 7/5/29

Plankton

Species	0-5	5-10	10-15	15-20
Ceratium	780	243	21	25
Dinobryum	55	21	4	
Aneura	12.8	21		8.5
Polyarthra				
Noltholca	8.5	8	8.5	
Asplancna	12.8		8.5	
Hexarthra	17	8		
Daphnia	14	4	1.6	4
Ostracod	4.2			
Diaptomus	35	.8	.8	
Cyclops	8	4.8	.8	11
Nauplii	29	17	4.2	4
Melosira	72	243	192	862
Fragillaria	315	119	81	25
Asterionella	76	29	12	4
Anabena				
Clathrocyctis	524	311	55	162
Oscillatoria	8	72	21	29
Lyngbya				

Dissolved Gases

D	T	O	%	CO_2	Cb
8	22.2	5.5		0	24.62
2	22.2	5.5		0	24.14
4	21.7	5.6		0	24.14
6	18.3	5.0		0	24.88
8	15.6	2.0		3.72	27.86
10	13.1	2.1		3.72	27.86
12	11.5	2.9		3.98	28.36
15	10.4	2.1		3.98	27.86
20	10.6	1.4		4.86	27.86
23	10.4	.84		5.22	28.10

TABLE 15.

LAKE: CROOKED (Whitley)
Date: 7/30/29

Plankton

Species	0-5	5-10	10-15	15-20
Ceratium	692	217	17	42
Dinobryum	4			
Aneura			4.2	
Polyarthra				
Noltholca	34			
Asplancna	5			4
Hexarthra	8	4		
Daphnia	8	3	2.4	3.2
Diaptomus	16	3	2.4	
Cyclops	1.6	7	2.4	3.8
Nauplii	4	8	4.2	4.2
Corethra				18
Melosira	34	64	140	128
Fragillaria	516	166	51	51
Asterionella	85	136	51	4
Anabena				
Clathrocyctis	866	507	254	183
Oscillatoria	162	42	29	34
Lyngbya				

Dissolved Gases

D	T	O	%	CO_2	Cb
S	26.7	5.84	103	0	22.92
2	26.1	5.89	103	0	22.44
4	23.9	6.11	103	0	23.42
6	21.1	4.44		2.44	23.18
8	16.7	.30		6.82	27.56
10	13.3	.61		5.02	28.54
12	11.7	1.33		4.88	26.84
15	10.9	.87		6.34	27.56
20	10.6	0		7.80	28.78
21	10.6	0		5.84	28.78

TABLE 16.

LAKE: CROOKED (Whitley)
Date: 8/15/30

Plankton

Species	0-5	5-10	10-30	15-30
Ceratium	55	42	4	
Dinobryum	8			
Aneura			166	
Polyarthra	102		46	
Noltholca		12.8	17	
Daphnia	.8	2.4	1.6	
Holopedium	4	4	.8	
Diaptomus	21	16	9.6	
Cyclops	22	12	29.6	
Nauplii	11.2	2	61	
Melosira		4.2		
Fragillaria	8.5	4.2		
Asterionella				
Anabena				
Clathrocyctis	785	1,147	354	
Oscillatoria	64	29	13	
Lyngbya				

Dissolved Gases

D	T	O	%	CO_2	Cb
S	26.1	5.56		—1.4	25.8
2	25	5.54		—1.0	25.8
4	24.4	5.28		—1.0	25.8
6	21.6	5.28		—1.6	25.8
8	13.5	5.15		—1.0	25.2
10	10	8.40	108	—1.4	29.0
12	8.5	7.29		—1.0	29.2
15	7.5	4.76		0	29.2
20	6.6	4.0		1.0	27.2
25	6.1	3.23		1.0	29.6
30	6.1	1.63		2.4	29.6

TABLE 17.

LAKE: CLEAR (Steuben)
Date: 7/15/29

Plankton						Dissolved Gases					
Species	0-5	5-10	10-15	15-20		D	T	O	%	CO_2	Cb
Ceratium	965	596	34	17		8	24.2	6.37	107	.02	24.96
Dinobryum	64	25				2	23.7	6.51	107	.98	24.46
Aneura	9.6	3.2	3.2	4		4	23.3	6.56	110	.98	24.98
Polyarthra			.8	1.6		6	21.1	6.57	107	.74	24.70
Noltholca			.8	1.6							
Triarthra			3.2	5.6		8	15.2	9.65	139	1.72	24.18
Daphnia	2.4	2.4	1.6	.8		10	12.7	5.79		1.62	27.18
Holopedium	1.6	.8				12	11.7	4.16		2.96	26.92
						15	11.1	3.30		2.70	27.98
Diaptomus	20	10	14	13.6							
Cyclops	26	18	6	2.4							
Nauplii	56	28	2.4	7.2		20	10.6	2.77		2.94	27.42
Melosira	328	3,672	132	114							
						25	10.6	2.48		2.94	26.68
Fragillaria											
Asterionella											
Anabena						30		1.65		2.94	27.18
Clathrocyctis	2,406	529	104	136		32	10.2				
Oscillatoria	64		4								
Lyngbya											

TABLE 18.

LAKE: CLEAR
Date: 8/5/29

Plankton

Species	0-5	5-10	10-15	15-20
Ceratium	320	72	25	8
Dinobryum	4			
Aneura	76	32	21	17
Polyarthra			4	
Noltholca	.8			4
Daphnia	1.6	4	1.6	3.2
Diaptomus	2.4	16.8	15	8.8
Cyclops	6.4	10.4	5.6	5.6
Nauplii	16.8	10.2	11	5.6
Melosira	68	12	46	128
Fragillaria	46	17	17	12
Asterionella				
Anabena	106	25	8	
Clathrocyctis	3,200	473	273	93
Oscillatoria	153	136	102	68
Lyngbya	537	1,036	209	

Dissolved Gases

D	T	O	%	CO_2	Cb
S	22.2	5.65		—.98	24.40
2	22.2	5.82		—.98	23.90
4	22	5.88		—.74	24.40
6	21.7	5.79		—.74	24.14
8	14 7	9.38	134	—1.74	26.38
10	12.5	4.25		2.98	27.38
12	11.7	2.44		3.48	27.62
15	10.9	1.60		4.22	28.38
20	10.6	1.19		4.72	27.38
25	1.6	.70		4.98	28.62
30		.08		5.72	28.18
32	10.4				

TABLE 19.

LAKE: FOX
Date: 7/10/29

Plankton					Dissolved Gases					
Species	0-5	5-10	10-15	15-20	D	T	O	%	CO_2	Cb
Ceratium	891	234	145		8	24.4	6.2	106	1.22	26.42
Dinobryum	8.5	8			2	24.2	6.2	106	.72	25.92
Aneura	12				4	21.9	6.2	102	.96	25.68
Polyarthra Asplanena	25	12.8	4.2		6	15.0	8.6	123		39.28
					8	12.8	1.8		4.40	31.06
Daphnia	4	4.8	5.6		10	11.1	.32		6.84	32.28
					12	11.1	0		7.32	32.52
					15	11.1	0		6.10	33.12
Diaptomus	20		2.4							
Cyclops	8		.8		17.5	10.8	0		5.12	33.12
Nauplii	25									
Corethra		192								
Melosira	51	12	8							
Fragillaria	17	85	349							
Asterionella	4	4	17							
Anabena	102		4							
Clathrocyctis	1,262	550	422							
Oscillatoria	686	256	8							
Lyngbya	31,091									

TABLE 20.

LAKE: GAGE
Date: 7/6/29

Plankton					Dissolved Gases					
Species	0-5	5-10	10-15	15-20	D	T	O	%	CO_2	Cb
Ceratium	477	128	140	46	8	22.2	5.9		.98	28.86
Dinobryum	1,710	46	499	72	2	22.2	5.9		.48	28.60
Aneura	8	38	42		4	20.9	6.1		.48	28.60
Hexarthra	29	4.2	17	4.2						
Polyarthra					6	20.6	6.0		.48	28.60
Noltholca	25	42	34	17						
Asplanena	21			4.2	8	14.4	11.2	158	2.98	28.86
Daphnia	13	5.6	.8	.8	10	12.5	4.3		2.48	29.34
Bosmina	1.6				12	11.5	4.0		4.96	30.34
					15	10.9	.03		4.46	31.48
Diaptomus	36	4.8	1.6							
Cyclops	16	24	3.2	1.6						
Nauplii	55	12.8	4							
					21.5	10.6	0		5.46	31.48
Corethra		1.6	.8							
Melosira	157	4	55	25						
Fragillaria	857	170	392	157						
Asterionella	106		17	4.2						
Anabena	42	12								
Clathrocyctis	1,608	302	226	38						
Oscillatoria										
Lyngbya	1,220	74,133	1,933	200						

TABLE 21.

LAKE: GAGE
Date: 8/3/29

Plankton

Species	0-5	5-10	10-15	15-20
Ceratium		153.6	51	51
Dinobryum		332.8	332	92
Aneura		45	10	15
Polyarthra				
Noltholca		81.9	20	5
Daphnia		7.6		
Asplancna		35		
Diaptomus		.9		.9
Cyclops		4.8	8	.9
Nauplii		29.4	5	.9
Corethra		2	5	
Melosira		225	122	9.2
Fragillaria		40	5	20
Asterionella		35		
Anabena		5		
Clathrocyctis		97	302	97
Oscillatoria				5
Lyngbya		43,950	936	424.9

Dissolved Gases

D	T	O	%	CO_2	Cb
S	24.4	5.31		0	26.64
2	24.4	5.16		0	27.63
4	23.9	5.17		0	26.89
6	20.4	5.05		0	27.39
8	15	10.64	153	—1.24	24.65
10	12.8	1.31		3.98	29.88
12	11.7	.27		5.00	30.37
15	11.1	0		4.98	30.87
21	10.6	0		8.46	39.54

TABLE 22.

LAKE: GEORGE
Date: 7/8/29

Plankton

Species	0-5	5-10	10-15	15-20
Ceratium	2,056	413	59	8
Dinobryum	93	17	4	
Aneura	8.5	4.2		
Noltholca		8.5		
Polyarthra				
Asplanena	8.5			
Hexarthra	34	4.2		
Daphnia	1.6	9.6	23	6
Diaptomus	17	12	3	
Cyclops	3.2	2.4	4.8	2
Nauplii	34	8	17	3
Corethra		1		
Melosira	55	25	85	64
Fragillaria	1,373	149	136	17
Asterionella	34	8	29.8	4
Anabena				
Clathrocyctis	469	597	213	123
Oscillatoria	110	51	21	17
Lyngbya Spir	21	8	8	

Dissolved Gases

D	T	O	%	CO_2	Cb
8	23.35	5.7			30.60
2	23.1	5.7			28.86
4	23.0	5.7			28.60
6	21.1	5.4			29.34
8	15.9	4.2		1.76	31.94
10	13.9	4.1		3.22	32.34
12	12.5	3.2		2.72	30.60
15	12.0	2.0		5.96	33.32
20	11.1	1.2		4.26	33.32
25	11.1	.93		5.46	33.08

TABLE 23.

LAKE: GEORGE
Date: 8/2/29

Plankton

Species	0-5	5-10	10-15	15-20
Ceratium	341	42	12.8	34
Dinobryum	29			
Aneura	28	59	2.4	
Polyarthra	2	1.6		
Daphnia	.8	2.4	1.6	5.6
Holopedium	.8			
Diaptomus	4.8	11.2	.8	4
Cyclops	6.4	13.5	3.2	4.8
Nauplii	16		2.4	4
Corethra			.8	
Melosira				
Fragillaria	1,211	281	133	93
Asterionella				
Anabena				
Clathrocyctis	859	1,156	1,830	204
Oscillatoria				
Lyngbya				

Dissolved Gases

D	T	O	%	CO_2	Cb
S	25.6	6.22	108	0	27.62
2	25.4	6.36	111	0	27.38
4	25.4	6.02	105	0	28.12
6	21.7	5.21		0	28.88
8	17	1.45		3.98	30.86
10	13.9	2.01		4.22	31.86
12	12.5	1.62		5.98	32.36
15	11.7	.41		5.98	33.00
20	11.1	.06		6.72	33.36
25	11.1	.10		6.42	34.86

TABLE 24.

LAKE: GOLDEN
Date: 7/25/29

Plankton					Dissolved Gases					
Species	0-5	5-10	10-15	15-20	D	T	O	%	CO_2	Cb
Ceratium	891	153.6			8	26.1	5.07		3.18	46.0
Dinobryum	46	93			2	23.9	4.92		4.42	48.6
Aneura	81	17			4	18.9	.89		13.28	46.74
Polyarthra					6	13.7	.09		13.76	48.70
Noltholca	123	8								
Asplancna	85	4								
Hexarthra	34				9.5	11.7	0		18.44	63.46
Daphnia	25	5								
Diaptomus	3									
Cyclops	16									
Nauplii	48	8								
Pediastrum	8.5									
Melosira	3,784	878								
Fragillaria	6,417	768								
Asterionella	9,975	2,551								
Anabena										
Clathrocyctis	405	145								
Oscillatoria	1,331	29								
Lyngbya	550	102								

TABLE 25.

LAKE: HAMILTON
Date: 7/11/29

Plankton					Dissolved Gases					
Species	0-5	5-10	10-15	15-19	D	T	O	%	CO_2	Cb
Ceratium	729	64	25	17	S	24.4	7.1	122	1.22	26.44
Dinobryum	51	4			2	24.4	7.1	122	.98	25.20
Aneura	85	17	4		4	23.1	6.3	105	.48	25.96
Hexarthra	46.9									
Polyarthra					6	18.9	4.3		.98	27.18
Noltholca	8.5	4								
Asplancna	42	17		29	8	14.4	1.42		5.18	28.66
Triarthra	4.2			4						
Daphnia	7.5	14	6	8.8	10	13.6	1.28		6.92	29.64
Pediastrum		8.5			12	13.3	1.20		6.92	29.64
					15	12.5	.7		6.16	29.64
Diaptomus	28	4.8								
Cyclops	2	12	13							
					19	11.7	.0		9.62	30.38
Nauplii	123	49		15						
Melosira	209	243	192	64						
Fragillaria	4,501	823	460	260						
Asterionella	307	72	4							
Anabena	273	4								
Clathrocyctis	3,426	964	354	217						
Oscillatoria	42	8	21							
Lyngbya										

TABLE 26.

LAKE: HAMILTON

Date: 7/31/29

Plankton					Dissolved Gases					
Species	0-5	5-10	10-15	15-20	D	T	O	%	CO_2	Cb
Ceratium	174	25	4.6	12	S	27.2	6.48	116	—.72	24.40
Dinobryum	2.8				2	26.9	6.47	115	—.48	23.42
Aneura					4	23.9	6.08	103	0	24.4
Polyarthra				4.6	6	20	2.74		2.68	26.58
					8	15.4	.31		5.60	28.78
Daphnia pulex	1	4		1.6	10	13.9	.31		8.28	29.76
D. retrocurva	28				12	13.3	.06		6.40	30.00
					15	12.8	0		7.32	29.02
Diaptomus	4		5.6							
Cyclops	8.8	17	4.8	2.4	19	11.7	0			
Nauplii	61	40		7.2						
Melosira	51	102	21							
Fragillaria	256	68		46.9						
Asterionella	38	89	12.8	12.8						
Anabena	332	38								
Clathrocyctis	3,306	1,079	294	273						
Oscillatoria	17									
Lyngbya										

TABLE 27.

LAKE: HOG
Date: 7/23/29

Plankton						Dissolved Gases					
Species	0-5	5-9	10-15	15-20		D	T	O	%	CO_2	Cb
Ceratium	1,058	268				S	26.6	5.98	106	0	27.80
Dinobryum	4,151	529				2	26.6	5.76	102	0	28.24
Aneura	8					4	23.9	6.25	106	0	28.60
Polyarthra						6	19.4	5.21		3.40	31.32
Asplancna	51	25									
Hexarthra	128	21				9	13.3	.34		6.62	38.54
Daphnia	5.6	4.8									
Diaptomus	6.4	4.8									
Cyclops	12	4.8									
Nauplii	24.8	28									
Melosira	17	12									
Fragillaria	2,124	419									
Asterionella		8									
Anabena		4									
Clathrocyctis	1,356	435									
Oscillatoria											
Lyngbya		268									

TABLE 28.

LAKE: HOG BACK
Date: 7/24/29

Plankton						Dissolved Gases					
Species	0-5	5-8	10-15	15-20		D	T	O	%	CO_2	Cb
Ceratium	3,741	567				S	24.7	4.90		0	40.28
Dinobryum	89	21				2	23.6	5.01		0	40.74
Aneura	179	12.8				4	19.4	.54		5.90	42.44
Polyarthra		51				6	14.4	0		12.02	44.94
Hexarthra	46	4									
Noltholca	140					8	13.9	0		16.78	48.12
Asplancna	200	25									
Daphnia	40	3									
Diaptomus	4.8	.8									
Cyclops	56	1.6									
Nauplii	115	12.8									
Melosira	4,906	503									
Fragillaria	1,463	512									
Tabellaria	55										
Asterionella	13,644	2,990									
Anabena	34										
Clathrocyctis	1,288	277									
Oscillatoria		213									
Pediastrum	38										
Lyngbya	3,946	750									

TABLE 29.

LAKE: JAMES LAKE, Station N.
Date: 6/19/29

Plankton — Dissolved Gases

Species	0-5	5-10	10-15	15-20		D	T	O	%	CO_2	Cb
Ceratium	2,448	332	284	11		S	24.4	6.1	104		39.96
Dinobryum	19,051	288	136	21		2	23.3	6.2	104		38.42
Aneura	25	3	7	12		4	20.8	6.5	105		37.92
Triarthra				8							
Polyarthra		1				6	17.8	6.8	103		37.40
Noltholca	1		2			8	13.75	6.3		1.26	38.92
Asplancna				1							
Daphnia	4.5	6	4	6		10	12.8	5.1		1.50	38.92
Holopedium	113					12	11.4	5.4		1.50	37.92
						15	10	5.2		1.50	38.92
Diaptomus	12	89		4							
Cyclops	13	64		5							
Nauplii	19	64		4		20	7.3	4.8		1.50	38.42
Melosira	7,597		236	217		25	6.7	2.3		3.52	38.92
Fragillaria	9,525	5,040	1,752	1,203							
Asterionella	567	226	106	196							
Anabena				179							
Clathrocyctis	11,680	204									
Oscillatoria	226		12								
Lyngbya											

TABLE 30.

LAKE: JAMES, Station B.
Date: 6/21/29

Plankton

Species	0-5	5-10	10-15	15-20
Ceratium	1,105	298	76	93
Dinobryum	3,357	439	149	51
Aneura	42	4.2	17	49
Hexarthra			4.2	
Polyarthra				4.2
Noltholca	8	12.8	4	4.8
Triarthra		8.5	1.6	12
Asplancna				4.2
Daphnia	8	8.8	8.8	12.8
Diaptomus	8.8	4.8	14.4	10.4
Cyclops	21.6	3.2	7.2	5.6
Nauplii	42	29	4	29.6
Melosira	422	51	119	294
Fragillaria	849	772	1,186	2,769
Asterionella	273	435	362	593
Anabena				
Clathrocyctis	1,809	430	221	264
Oscillatoria	38	55	221	12
Lyngbya	558	98	72	25

Dissolved Gases

D	T	O	%	CO_2	Cb
S	24.2	6.0	103	—.50	37.40
2	23.9	6.1	104	.74	36.90
4	21.4	6.3	103	—.74	36.40
6	16.9	6.4		—.50	37.66
8	14.4	6.1		0	37.40
10	14.2	5.8		1.50	38.42
12	13.3	4.7		.50	37.66
15	13.1	4.0		.62	37.92
20	11.7	2.0		1.38	39.18

TABLE 31.

LAKE: JAMES, Station I.
Date: 6/26/29

Plankton

Species	0-5	5-10	10-15	15-20
Ceratium	2,321	422	179	51
Dinobryum	977	166	17	21
Aneura	38	17	38	51
Polyarthra				
Noltholca	12	8	8	
Triarthra	4		8	21
Hexarthra	4	4	8	
Daphnia	20	4	7.2	8
Diaptomus	15	11	10	4.8
Cyclops	82	6	9	4.8
Nauplii	11	34	6	11.2
Corethra		.8		
Melosira	64	68	102	435
Fragillaria	2,180	1,326	1,258	2,112
Asterionella	256	422	170	136
Anabena				
Clathrocyctis	5,491	1,160	516	733
Oscillatoria	81	64	8.5	46
Lyngbya	226	631	388	51

Dissolved Gases

D	T	O	%	CO_2	Cb
S	23.3	6.3	106	1.21	35.76
2	23.3	6.4	108	.98	35.76
4	20.6	7.2	116	.72	35.76
6	16.7	7.4	110	0	36.0
8	13.9	6.9		.98	36.50
10	12.8	5.9		2.20	36.50
12	11.7	4.8		4.40	37.91
15	10.3	5.4		3.42	36.74
20	8.9	2.6		4.90	37.24
22	8.9	1.5		5.62	37.24

TABLE 32.

LAKE: JAMES, Station E.
Date: 7/2/29

Plankton						Dissolved Gases					
Species	0-18	5-10	10-15	15-20		D	T	O	%	CO_2	Cb
Ceratium	1,194					8	22.2	7.1	116	—1.55	36.21
Dinobryum	8					2	22.2	7.0	116	—1.03	36.72
Aneura	52					4	22.2	7.2	116	—1.03	36.46
Polyarthra	13					6	18.9	7.0	109	0	36.98
Noltholca	20					8	14.7	6.8		1.29	37.76
Daphnia	1.7					10	13.7	5.7		1.81	38.03
						12	13.3	4.3		3.10	38.53
Diaptomus	18.7					15	13.1	3.7		2.30	38.02
Cyclops	19.5					17	12.8	2.7		2.84	38.28
Nauplii	19.3										
Melosira	210										
Fragillaria	4,222										
Asterionella	722										
Anabena	4										
Clathrocyctis	56										
Oscillatoria											
Lyngbya	194										

TABLE 33.

LAKE: JAMES, Station U.
Date: 7/2/29

Plankton						Dissolved Gases					
Species	0-18	5-10	10-15	15-20		D	T	O	%	CO_2	Cb
Ceratium	610					S	22.1				
Dinobryum	74					2	21.7				
Aneura	35					4	21.1	7.01	114	—1.03	37.50
Polyarthra	11					6	16.4	7.07	104	.26	38.02
Noltholca	9					8	13.9	6.7		1.03	39.05
Daphnia	3.7					10	12.8	6.2		1.55	39.57
						12	11.1	5.5		1.81	38.02
						15	10.2	4.3		3.10	38.28
Diaptomus	14										
Cyclops	13					18	10	4.1		4.13	38.79
Nauplii	13										
Melosira	158										
Fragillaria	3,011										
Asterionella	389										
Anabena											
Clathrocyctis	37										
Oscillatoria											
Lyngbya	483										

TABLE 34.

LAKE: JAMES, Station M.
Date: 7/4/29

Plankton						Dissolved Gases					
Species	0-5	5-10	10-15	15-20		D	T	O	%	CO_2	Cb
Ceratium	648					S	21.4				
Dinobryum	76					2	21.4				
Aneura	39					4	21.4	6.2	101	—.75	37.16
Polyarthra	14					6	18.9	6.0		—.50	36.90
Noltholca	11					8	14.7	6.3		1.26	37.66
Daphnia	4					10	13.7	5.4		1.76	39.67
						12	11.7	4.7		1.76	37.66
						15	10	3.7		2.52	38.42
Diaptomus	13.9										
Cyclops	12.6										
						19	9.7	3.2		3.53	39.17
Nauplii	27.0										
Melosira	176										
Fragillaria	3,450										
Asterionella	436										
Anabena	1										
Clathrocyctis	90										
Oscillatoria	34										
Lyngbya	614										

TABLE 35.

LAKE: JAMES, Station N.
Date: 8/6/29

Plankton						Dissolved Gases					
Species	0-5	5-10	10-15	15-20		D	T	O	%	CO_2	Cb
Ceratium	1,271	234	85	140		8	22.8	5.90		0	34.36
Dinobryum	21	17	4			2	22.2	5.80		0	33.86
Aneura	243	38		12		4	22.2	5.90		0	32.10
Polyarthra	12					6	20.9	5.74		0	32.16
Noltholca		4	4			8	15.5	5.79		.98	37.10
Daphnia	4	6	2.4	2.4		10	13.3	3.59		3.22	38.34
						12	11.7	2.71		4.22	37.58
						15	10.6	2.59		5.22	38.34
Diaptomus	3.2	4.8		8							
Cyclops	18.4	12	2.4	5.6		20	8.3	2.77		5.46	38.34
Nauplii	53.6	15.2	4	5.6							
Melosira	42	42	25	38		25 26	7.1	.06		7.96	40.08
Fragillaria	533	315	149	179							
Asterionella											
Anabena	21	51		12							
Clathrocyctis	256	793	170	64							
Oscillatoria	183	332	76	128							
Lyngbya											

TABLE 36.

LAKE: JAMES, Station L.
Date: 8/7/29

Plankton						Dissolved Gases					
Species	0-5	5-12	10-15	15-20		D	T	O	%	CO_2	Cb
Ceratium	115	136				S	22.2	5.82		0	35.10
Dinobryum	8.5	21				2	22.2	5.66		0	34.60
Aneura	42	.8				4	22.2	5.73		0	34.10
Polyarthra						6	21.7	5.36		0	34.10
						8	15.3	4.0		2.72	37.34
Daphnia	14	9.6				10	13.7	2.54		4.72	39.08
						12	11.9	2.43		4.48	38.34
Diaptomus	5.6	9.6									
Cyclops	29.6	16									
Nauplii	64	12.8									
Melosira	25	17									
Fragillaria	149	213									
Asterionella		4									
Anabena	8										
Clathrocyctis	55	388									
Oscillatoria	149	46									
Lyngbya	4	59									

TABLE 37.

LAKE: JAMES, Station B.
Date: 8/7/29

Plankton					Dissolved Gases					
Species	0-5	5-10	10-15	15-20	D	T	O	%	CO_2	Cb
Ceratium	435	256	68	42	S	22.5	5.70		0	34.98
					2	22.2	5.94		0	34.22
Dinobryum	12				4	22.2	5.33		0	33.86
Aneura	85	25	8.5	8.5						
Hexarthra		12.8			6	21.4	5.51		0	34.48
Polyarthra										
Noltholca	4				8	16.1	4.43		3.98	38.08
Triarthra			4.2		10	13.9	2.35		4.72	39.08
Daphnia	4	3.2			12	13.3	1.34		4.98	38.08
					15	13.3	.58		6.22	38.34
Diaptomus	7	8.8	10	.8						
Cyclops	8	7.2	5.6	1.6	20	12.2	.09		6.22	39.58
Nauplii	34	29	4	.8						
Corethra			4							
Melosira	68	25	17	12.8						
Fragillaria	209	285	72	119						
Asterionella										
Anabena										
Clathrocyctis	563	742	247	226						
Oscillatoria	64	42	21	46						
Lyngbya	59	90	8	17						

TABLE 38.

LAKE: JAMES, Station J.
Date: 8/8/29

Plankton						Dissolved Gases					
Species	0-5	5-10	10-15	15-20		D	T	O	%	CO_2	Cb
Ceratium	465	200	51	12		S	22.8	5.99	100	0	34.60
						2	22.8	6.09	102	0	33.10
Dinobryum	12		4								
						4	22.5	5.68		0	33.36
Aneura	42	8	8	17							
						6	20	5.35		0	33.86
Polyarthra											
Noltholca	4.2		4	8		8	15.6	4.32		.24	33.84
Hexarthra	4.2										
						10	13.1	3.68		4.72	38.58
Daphnia	14.4	4	.8	14							
						12	11.9	2.97		4.48	37.84
						15	10.3	2.70		6.72	37.34
Diaptomus	13	9.6	4.8	8							
Cyclops	32	6.4	6.4	5.6							
						20					
Nauplii	16	4.8	2.4	2.4		21	8.9	.13		7.96	39.58
Melosira	68	8	46	64							
Fragillaria	196	149	55	81							
Asterionella	8	4									
Anabena	29										
Clathrocyctis	435	1,181	516	554							
Oscillatoria	776	25	25	17							
Lyngbya	12	25	17	17							
Synedra			17	4							

TABLE 39.

LAKE: JAMES, Station I.
Date: 8/9/29

Plankton						Dissolved Gases					
Species	0-23	5-10	10-15	15-20		D	T	O	%	CO_2	Cb
Ceratium	345					S	23	6.12	102	0	34.12
Dinobryum						2	23	6.01	101	0	33.62
Aneura	41					4	22.6	6.24	104	0	33.38
Polyarthra	4.7					6	20.9	5.70		0	33.62
Noltholca	7.1					8	15	4.05		4.0	27.30
Daphnia	5.9					10	13.3	3.80		5.14	29.02
						12	11.9	2.58		5.88	37.56
						15	10	2.12		5.88	38.54
Diaptomus	9.9										
Cyclops	16.9										
Nauplii	12.8										
						23	8.6	.17		8.34	40.26
Melosira	58										
Fragillaria	402										
Asterionella											
Anabena	2										
Clathrocyctis	48										
Oscillatoria	42										
Lyngbya	61										

TABLE 40.

LAKE: JAMES, Station N.
Date: 8/14/30

Plankton						Dissolved Gases					
Species	0-5	5-10	10-15	15-20		D	T	O	%	CO_2	Cb
Ceratium	887	149	55	21		8	24.4	5.42		—1.2	33.2
Mallomonas	4		8.5								
Dinobryum	21	8	4			2	23.6	5.45		—2.4	35.6
Aneura	149	29	4	17		4	23.3	5.39		—2.6	34.8
Polyarthra	29	51				6	23.3	5.13		—2.0	35.6
Noltholca		12		4							
Asplancna	4					8	15	3.67		0	40.0
Daphnia		6.4	.8	4		10	11.5	3.25		1.0	41.4
						12	9.1	2.97		1.0	40.8
						15	8.1	2.71		1.0	41.4
Diaptomus	14	20	.8	1.6							
Cyclops	47	12	2.4	3.2							
Nauplii	857	7	.8	9.6		20	6.6	2.44		1.4	41.4
Melosira	81	51	12	46							
						25	6.1	.08		1.4	42.8
Fragillaria	529	247	38								
Asterionella											
Anabena	12	8	4								
Clathrocyctis	588	337	64	59							
Oscillatoria	81	136	25	59							
Lyngbya											

TABLE 41.

LAKE: JAMES (3rd Basin)
Date: 8/22/30

Plankton

Species	0-5	5-10	10-15	15-20
Ceratium	1,032	204	145	145
Mallomonas	140	17	17	
Dinobryum	34	12	21	
Uroglea	89	29		8
Aneura	68	46	29	46
Difflugia	138		17	25
Polyarthra	21	4		
Noltholca	12		21	34
Daphnia	4.8	1.6	2.4	10.4
Diaphanosoma	2.4	2.4		3.2
Diaptomus	27	7.2	8.8	14
Cyclops	25	26.4	12.8	18.4
Nauplii	56	11.2	23.2	26.4
Melosira	174	76	136	140
Fragillaria	840	282	187	174
Asterionella				
Anabena	46	8.5	4	
Clathrocyctis	465	541	401	264
Oscillatoria	106	17	25	128
Lyngbya	132		46	81

Dissolved Gases

D	T	O	%	CO_2	Cb	pH
S	22.2	5.71		—1.4	34.4	8.3
2	22.2	5.80		—2.0	34.6	8.3
4	22.2	5.92		—1.4	34.0	8.3
6	22.2	5.83		—2.0	33.8	8.3
8	15.2	5.61		.4	35.8	7.8
10	11.6	2.90		.6	40.4	7.6
12	9.4	2.72		1.0	41.0	7.6
15	7.9	2.11		1.6	40.4	7.5
20	7.2	2.45		2.0	40	7.5
25	6.2	.06		2.4	41.4	7.2

TABLE 42.

LAKE: JAMES (3rd Basin)
Date: 8/30/30

	Plankton				Dissolved Gases						
Species	0-5	5-10	10-15	15-20	D	T	O	%	CO_2	Cb	pH
Ceratium					S	23.3	5.71		—2.2	33.8	8.3
Dinobryum					2	23	6.42	107	—2.4	33.6	
Aneura					4	22.4	6.07	101	—2.6	34.4	
Polyarthra					6	21.6	5.73		—2.0	34.4	
					8	16.1	3.39		1.2	37.8	
Daphnia					10	11.7	2.56		2.8	40.4	
					12	9.7	2.07		2.8	44	
					15	7.8	2.18		2.8	40.4	
Diaptomus											
Cyclops											
Nauplii					20	6.9	2.42		2.0	40.4	
Melosira											
					25.5	6.2	.10		2.8	43.6	7.5
Fragillaria											
Asterionella											
Anabena											
Clathrocyctis											
Oscillatoria											
Lyngbya											

TABLE 48.

LAKE: JAMES (3rd Basin)
Date: 9/7/30

Plankton					Dissolved Gases					
Species	0-5	5-10	10-15	15-25	D	T	O	%	CO_2	Cb
Uroglea	691	81								
Ceratium	1,484	328	106	145	S	22.2	5.88		—1.6	33.4
Dinobryum	55	29	4		2	22.2	6.11	101	—1.6	34.2
Mallomonas	110	34	17.1	21						
Aneura	85	8	4.2	59	4	22.2	6.06	100	—2.4	32.8
Polyarthra		38	17.1	12	6	21.6	5.82		—2.4	32.8
Triarthra	12.8									
Noltholca		8	8.5	8	8	16.1	3.70		0	35.6
Daphnia	4	1.6	7.2	6.2	10	11.6	2.10		.4	37.0
Bosmina	2.4									
Diaphanosma		.8	12.8	.8	12	10	1.95		1.4	39.6
					15	8.0	1.76		1.4	41.0
Diaptomus	4.8	8								
Cyclops	16.8	9.6	8	5.6						
Nauplii	21.6	10.8	12.8	9.6	20	6.9	1.72		2.0	42.0
Melosira	85	72	81	85						
					25	6.6	.07		2.4	42.0
Fragillaria	1,766	814	405	192						
Asterionella										
Anabena	354	25	46							
Clathrocyctis	98	477	106	264						
Oscillatoria	106	72	72	46						
Lyngbya		166								

TABLE 44.

LAKE: JAMES (3rd Basin) N.
Date: 9/20/30

Plankton					Dissolved Gases					
Species	0-5	5-10	10-15	15-20	D	T	O	%	CO_2	Cb
Difflugia	59	17	17							
Ceratium	704	311	81	76	S	21.1	5.11		—1.25	33.4
Uroglea	302	38	12	8						
Dinobryum	132	46	17	30	2					
Mallomonas	21	33	25	8						
Aneura	81	61	34	38	4					
Polyarthra	34		12		6	20.5	5.56		0	33.4
Noltholca	4.2			8						
Asplancna	4.2				8	16.3	4.21		1.0	34.8
					9	13.8				
Daphnia	.8	.8	2.4	2.4	10	12.2	1.19		7.10	50.4
Bosmina		.8			12	9.4	1.10		1.50	40.0
Diaphanosoma		1.6								
					15	8	1.61		3.02	40.4
Diaptomus	.8	13.6	4	4						
Cyclops	7.2	14.4	9.6	3.2						
Nauplii	14.4	13.6	14.4	8	20	7.0	1.55		3.02	40.4
Melosira	64	38	38.4	30.8	24.5	6.6	.12		4.06	41.8
Fragillaria	1,339	1,651	494	264						
Asterionella										
Anabena	21		8.5							
Clathrocyctis	252	512	166	187						
Oscillatoria	140	93	17	30						
Lyngbya	115	106	57							

TABLE 45.

LAKE: JIMMERSON
Date: 7/19/29

Plankton

Species	0-5	5-10	10-17	15-20
Ceratium	2,205	588	76	
Dinobryum	302	46	4	
Aneura	247	51	8	
Polyarthra				
Noltholca		12	4	
Asplancna	4.2		8	
Hexarthra	59	29		
Daphnia	6.4	6	2.4	
Bosmina	.8			
Diaptomus	8	33		
Cyclops	21.6	14	1.6	
Nauplii	46	34	4.8	
Corethra	.8			
Melosira	136	136	85	
Fragillaria	3,200	1,557	242	
Asterionella	55	29	12	
Anabena	8	8		
Clathrocyctis	682	576	614	
Oscillatoria	72	21	17	
Lyngbya	115	413	136	

Dissolved Gases

D	T	O	%	CO_2	Cb
S	24.4	5.57		0	33.10
2	24.4	5.57		0	32.62
4	24.2	4.53		0	32.38
6	17.2	4.99		2.70	34.10
8	13.9	3.26		2.70	37.56
10	12.2	1.77		4.94	39.54
12	11.1	.47		6.92	38.54
17	10	.06		5.68	39.56

TABLE 46.

LAKE: LONG (Steuben)
Date: 7/25/29

Plankton					Dissolved Gases					
Species	0-5	5-9	10-15	15-20	D	T	O	%	CO_2	Cb
Ceratium	1,493	362			8	24.4	5.33		4.18	47.72
Dinobryum	435	119			2	21.9	5.24		5.40	48.94
Aneura	119	29			4	17.2	1.16		7.04	49.44
Polyarthra					6	14.4	.11		11.56	47.46
Noltholca	29	12								
Hexarthra	4	4			8					
Daphnia	48	1.6			9.5	12.2	0		15.74	57.06
Diaptomus	14	1.6								
Cyclops	24	2.4								
Nauplii	68	10								
Melosira	10,146	2,986								
Fragillaria	8,072	3,566								
Asterionella	4,962	4,232								
Anabena										
Clathrocyctis	170	64								
Oscillatoria										
Lyngbya	998	298								

TABLE 47.

LAKE: LOON
Date: 7/26/29

Plankton						Dissolved Gases					
Species	0-4	5-10	10-15	15-20		D	T	O	%	CO_2	Cb
Ceratium	823					S	26.7	4.76		1.98	24.10
Dinobryum	17					2	25.6	4.42		1.16	23.86
Aneura	174					4	21.4	1.99		3.92	25.82
Polyarthra											
Triarthra	17										
Hexarthra	12										
Daphnia	30										
Diaptomus	11										
Cyclops	3.2										
Nauplii	47										
Melosira	4										
Fragillaria	8										
Asterionella	221										
Anabena											
Clathrocyctis	563										
Oscillatoria											
Lyngbya											

TABLE 48.

LAKE: LONG LAKE (N. Basin)
Date: 8/20/30

Plankton

Species	0-5	5-10	10-18	15-20
Ceratium	51	34	8	
Dinobryum	209	4,364	665	
Aneura	8	4		
Polyarthra		4.2		
Hexarthra	8			
Noltholca	8		4	
Daphnia	6.4	19	2.4	
Diaptomus	37	12		
Cyclops	15	52	6.4	
Nauplii	55	115	2.4	
Melosira	4	64	17	
Fragillaria	4	4		
Asterionella				
Anabena	170	81	8	
Clathrocyctis	4,535	2,905	401	
Oscillatoria	89	76	25	
Lyngbya	341	746	17	

Dissolved Gases

D	T	O	%	CO_2	Cb
8	23.8	4.43		—1.0	23.2
2	23.8	4.51		—2.4	23.2
4	23.5	4.43		—2.4	23.2
6	21.3	4.85		1.4	23.2
8	13.3	1.95		.4	30.4
10	10.5	.35		1.2	29.8
12	10	.17		1.0	30.8
15	9.4	.05		.6	30.8
18	8.8	.05		1.4	32.2

TABLE 49.

LAKE: LONG LAKE (S. Basin) (LaGrange)
Date: 8/20/30

Plankton					Dissolved Gases						
Species	0-5	5-10	10-15	15-21	D	T	O	%	CO_2	Cb	pH
Ceratium	140	42	8.5	2	S	23.8	5.03		—1.6	23.8	8.3
Dinobryum	311	759	657	106	2	23.8	5.15		—1.6	22.6	8.3
Aneura		8.5			4	23.5	5.13		—1.2	23.2	8.3
Polyarthra					6	21.6	4.51		—1.0	23.6	8.3
Asplancna	4										
Noltholca				4	8	12.7	1.53		1.0	29.6	7.5
Daphnia	8	.8	12	1.6	10	10.5	.31		1.0	29.8	7.1
Leptodera	.8				12	10	.34		2.0	29.8	7.1
					15	9.0	.08		2.0	30.2	7.1
Diaptomus	16	4	1.6	.8							
Cyclops	24	18	12	1.6							
Nauplii	98	55	23	1.6							
					22	8.8	.005		2.2	31.2	7.1
Melosira	8	21	17								
Fragillaria	38	12	85	4							
Asterionella											
Anabena	234	55	12								
Clathrocyctis	3,549	1,267	652	251							
Oscillatoria	123	38	34	25							
Lyngbya	311	499	136	25							

TABLE 50.

LAKE: OLIVER (LaGrange)
Date: 9/6/30

Plankton

Species	0-5	5-10	10-15	15-25
Ceratium	1,083	1,024	251	51
Dinobryum	21			
Aneura	76	34		21
Hexarthra	8.5			
Polyarthra	51	4.2		12
Noltholca	4.2	4.2	2.4	12
Asplancna	4.2			
Daphnia	3.2	3.2	.8	8.8
Bosmina	4			
Holopedium	3.2			
Diaptomus	9.6	5.6	8.8	4.8
Cyclops	5.6	17	23	24
Nauplii	24	16	28	76
Melosira	17	162	311	678
Fragillaria	234	128	106	64
Asterionella	4	21		
Anabena	4	34	128	
Clathrocyctis	260	371	166	140
Oscillatoria	85	38	64	25
Lyngbya				

Dissolved Gases

D	T	O	%	CO_2	Cb	pH
S	25	5.53		—.6	32.8	8.2
2	22.2	6.10	101	—3.0	33.6	8.2
4	22.2	6.07	100	—3.2	33.8	8.2
6	21.2	5.09		—2.0	33.8	8.2
8	15.5	5.33		0	37.4	7.9
10	10.5	4.51		.6	40.4	7.6
12	8.8	3.84		1.2	39.4	7.6
15	8.3	2.81		1.0	40.4	7.5
20	7.7	1.03		1.0	41.8	7.5
25	7.7	.21		2.2	41.8	7.5

TABLE 51.

LAKE: LOWER OTTER
Date: 7/18/29

Plankton						Dissolved Gases					
Species	0-5	5-12	10-15	15-20		D	T	O	%	CO_2	Cb
Ceratium	68	16				S	24.8	6.15	106	.0	42.00
Dinobryum	162					2	24.8	6.10	106	.0	42.00
Aneura	12.8					4	21.7	5.78		.0	41.52
Polyarthra Noltholca	.8					6	14.7	4.11		2.20	40.02
						8	10.9	3.36		3.56	39.54
Daphnia	8	3.2				10	10.6	.57		7.52	39.54
						12	10	.11		6.92	40.02
Diaptomus	4.8										
Cyclops	19.2	9.6									
Nauplii	19.2	17.6									
Melosira		76									
Fragillaria	2,606	3,140									
Asterionella		40									
Anabena											
Clathrocyctis	904	1,975									
Oscillatoria	89	294									
Lyngbya											

TABLE 52.

LAKE: PLEASANT

Date: 7/9/29

Plankton

Species	0-5	5-10	10-13	15-20	
Ceratium	9,464	38,451	18,278		
Dinobryum	396	64	196		
Aneura	12.8	25			
Polyarthra					
Hexarthra	4	8	4		
Daphnia	8	4.8	2.4		
Diaptomus	12	4			
Cyclops	1.6	.8			
Nauplii	4	25	8.5		
Corethra		4	.8		
Melosira	200	294	110		
Fragillaria	51	8	17		
Tabellaria	1,506	332	631		
Asterionella		4	4		
Anabena	524	38	4		
Clathrocyctis	277	128	251		
Oscillatoria	38	8	8		
Lyngbya	42	64			

Dissolved Gases

D	T	O	%	CO_2	Cb
S	23.9	5.7		0	24.46
2	23.6	5.6		0	24.22
4	23.3	5.6		0	23.72
6	20	6.1		0	24.42
8	15.6	6.3		1.46	28.36
10	12.8	2.9		4.64	28.12
12					
13	11.7	67		5.12	29.84
15					
20					
25					
30					

TABLE 53.

LAKE: PLEASANT LAKE
Date: 7/23/29

Plankton						Dissolved Gases					
Species	0-5	5-10	10-15	15-20		D	T	O	%	CO_2	Cb
Ceratium	136	21				S	25.6	5.57		0	24.96
Dinobryum						2	25	5.42		0	25.06
Aneura						4	23	5.74		0	24.38
Polyarthra						6	22	4.60		1.80	24.50
Noltholca	1.6	4				8	17.2	.37		4.98	27.24
Hexarthra	12.8	4									
Daphnia	25	2.4				10	14.4	.09		4.54	28.60
Diaptomus	32	.8									
Cyclops	4	2.4									
Nauplii	38	29									
Melosira		12									
Fragillaria	81	25									
Asterionella		12									
Anabena											
Clathrocyctis	1,472	247									
Oscillatoria	17	12									
Lyngbya	17	42									

TABLE 54.

LAKE: PRETTY
Date: 8/18/30

Plankton					Dissolved Gases					
Species	0-5	5-10	10-15	15-20	D	T	O	%	CO_2	Cb
Ceratium	2,948	102	72	128	S	23.8	5.18		—2.4	26.8
Dinobryum	1,966	42	25	34	2	23.8	5.24		—1.4	27.6
*	106	68		25						
Aneura	264	12	4	5.6	4	23.3	5.16		—1.6	27.8
Hexarthra	17	12.8	4.2							
Polyarthra					6	21.8	4.64		— .8	27.8
Noltholca	8.5	1.6	8.5	8						
					8	14.7	1.62		.4	32.2
Asplancna	21	8.5								
Daphnia	12	3.2	1.6		10	10	.85		1.0	33.0
					12	9.4	.45		1.0	32.6
					15	8.8	.35		1.0	31.8
Diaptomus	44	4	2.4	.8						
Cyclops	18	12	3.2	1.6						
Nauplii	332	50	10.4	4	20	8.3	.03		1.0	32.2
Melosira	12	29	21	17	24.5	8.3	.04		1.0	31.8
Fragillaria	4,083	334	162	98						
Asterionella	4	4		4.2						
Anabena	42			4						
Clathrocyctis	563	742	115	102						
Oscillatoria	132	29	12	4						
Lyngbya	25	1,036	55	81						

TABLE 55.

LAKE: ROUND
Date: 8/12/30

Plankton						Dissolved Gases					
Species	0-5	5-10	10-15	15-20		D	T	O	%	CO_2	Cb
Ceratium	243	46	4.2			S	25	5.05	0	—1.0	22.4
Dinobryum	25.6					2	24.4	5.44		—1.0	21.6
Aneura	17	4.2				4	23.6	5.03		—1.4	21.6
Polyarthra						6	20.5	4.90		— .4	21.2
Asplancna	21										
Hexarthra	42	12.8				8	13.8	.24		3.0	28.8
Daphnia	7.2	1.6	1.6			10	10.5	.335		3.0	28.8
Bosmina		.8									
Diaptomus	14.4		.8								
Cyclops	20.8	3.2	.8			18	9.4	.0		3.0	31.2
Nauplii	68.2	25.6									
Melosira	38.4	38.4	64								
Fragillaria	2,517	409	132								
Asterionella		4.2									
Anabena	755	55	17								
Clathrocyctis	729	554	204								
Oscillatoria	98	25	85								
Lyngbya	17,937	742	593								

TABLE 56.

LAKE: SHRINER
Date: 8/15/30

Plankton					Dissolved Gases					
Species	0-5	5-10	10-15	15-20	D	T	O		CO_2	Cb
Ceratium	4	12	1		8	26.6	5.25		—1.4	23.6
Dinobryum	17	25	4		2	25.3	5.32		—1.0	24.2
		2,201	42							
Aneura					4	25	5.33		—1.4	24.2
Noltholca			.8							
Polyarthra		38			6	19.6	5.29		—1.2	23.6
Triarthra			2.4							
Hexarthra	17				8	12.7	6.63		0	26.2
Asplancna		1								
Daphnia	14	24	4.8		10	10.5	2.39		1.0	26.8
					12	7.77	1.23		2	26.8
					15	8.8	.14		2	27.6
Diaptomus	6.4	52	8							
Cyclops	1.6	19	2.4		18	8.6	.06		3.0	28.0
Nauplii	34	25	10							
Corethra		4								
Melosira		25	25							
Fragillaria	418	209	46							
Asterionella										
Anabena	132	277	34							
Clathrocyctis	341	725	358							
Oscillatoria	8		405							
Lyngbya		2,926	59							

TABLE 57.

LAKE: SILVER
Date: 7/24/29

Plankton					Dissolved Gases					
Species	0-5	5-11	10-15	15-20	D	T	O	%	CO_2	Cb
Ceratium	315	55			S	25	5.15		0	26.22
Dinobryum	264	64			2	24.7	5.06		0	26.54
Aneura	21				4	23.1	4.94		0	26.78
Polyarthra					6	17.7	.22		4.88	31.32
Noltholca	25									
Hexarthra	8				8	13.9	.10		6.34	31.32
Asplancna		4								
Daphnia	12	4			10					
					11	11.7	.0		8.16	36.08
Diaptomus	9.6	1.6								
Cyclops	4	.8								
Nauplii	47	4.2								
Melosira	140	217								
Fragillaria	102	17								
Asterionella	704	119								
Anabena	8									
Clathrocyctis	768	341								
Oscillatoria	140	34								
Lyngbya	17	320								

TABLE 58.

LAKE: SNOW, Station O.
Date: 6/22/29

Plankton

Species	0-5	5-10	10-15	15-20
Ceratium	640	55	42	38
Dinobryum	38	8.5	4	4.2
Aneura	72	4.2	12	17
Hexarthra	21	4.2		
Polyarthra				
Noltholca	12	17	17	4.2
Asplancna	12	4.2	4	12.8
Daphnia	10	4	2.4	1.6
Diaptomus	13	22	5.6	1.6
Cyclops	37	3.2	1.6	.8
Nauplii	44	25	25	10
Melosira	529	469	725	1,821
Fragillaria	733	297	460	384
Tabellaria			110	
Asterionella	85	98	34	140
Anabena	17	8		
Clathrocyctis	2,444	439	640	145
Oscillatoria	157	17		12
Lyngbya	315	34	59	46

Dissolved Gases

D	T	O	%	CO	Cb
8	24.7	5.6		.74	36.92
2	24.2	5.6		.74	36.40
4	19.4	6.4	100.7	.60	38.42
6	15.6	5.5		.50	38.42
8	13.7	4.9		.74	38.42
10	12.2	4.1		1.50	38.92
12	11.1	3.7		2.26	38.66
15	10.6	3.1		2.62	38.92
20	8.3	.15		3.02	37.92
25	7.2	0		6.66	40.44

TABLE 59.

LAKE: SNOW, Station Q.
Date: 7/3/29

Plankton					Dissolved Gases					
Species	0-18	5-10	10-15	15-20	D	T	O	%	CO_2	Cb
Ceratium	382				S	22.2	6.04		.75	35.64
Dinobryum	192				2	22.2	6.07		—.50	36.80
Aneura	31				4	20.9	6.0		—.50	37.41
Polyarthra	15				6	15.6	5.4		1.01	37.92
Noltholca	5				8	13.7	4.3		3.03	38.67
Daphnia	3.9				10	12.2	3.5		3.28	39.43
					12	11.1	3.3		3.53	38.67
Diaptomus	13.9				15	10.6	2.9		4.04	39.43
Cyclops	9.7				18	10.4	1.8		5.50	39.43
Nauplii	30.8									
Melosira	168									
Fragillaria	925									
Asterionella	53									
Anabena	7.8									
Clathrocyctis	132									
Oscillatoria	66									
Lyngbya	218									
Tabellaria	5.6									

TABLE 60.

LAKE: SNOW, Station S.
Date: 7/3/29

Plankton						Dissolved Gases					
Species	0-10	5-10	10-15	15-20		D	T	O	%	CO_2	Cb
Ceratium	324					8	21.7	6.1		—.5	36.15
Dinobryum	25					2	21.7	6.1		—.75	36.4
Aneura	25					4	20.9	6.1		—.25	36.15
Polyarthra	61					6	16.1	4.8		.75	38.42
Noltholca	8.5					8	14.2	2.5		3.28	38.93
Daphnia	5.6					10	12.8	1.03		5.30	39.94
Diaptomus	13.2										
Cyclops	8										
Nauplii	31.6										
Melosira	115										
Fragillaria	361										
Asterionella	121										
Anabena	8.5										
Clathrocyctis	140										
Oscillatoria	113										
Lyngbya	63										

TABLE 61.

LAKE: SNOW, Station P.
Date: 7/4/29

Plankton					Dissolved Gases					
Species	0-15	5-10	10-15	15-20	D	T	O	%	CO_2	Cb
Ceratium	238				S	21.4	6.0		—1.01	35.89
Dinobryum	133				2	21.1	6.0		— .50	36.15
Aneura	186				4	20	5.8		— .5	36.90
Polyarthra	14				6	15.8	4.8		1.51	36.65
Triarthra	7.9									
Noltholca	1.3				8	14.2	2.9		2.78	37.92
Daphnia	2.2				10	12.8	2.1		4.04	37.66
					12	11.4	.89		6.06	37.66
					15	10.6	.09		7.58	38.42
Diaptomus	17.5									
Cyclops	8.7									
Naupli:	26.2									
Melosira	56									
Fragillaria	754									
Asterionella	59									
Anabena										
Clathrocyctis	159									
Oscillatoria	50									
Lyngbya	186									

TABLE 62.

LAKE: SNOW, Station O.
Date: 8/6/29

Plankton

Species	0-5	5-10	10-15	15-20
Ceratium	840	106	51	34
Dinobryum	516	12	8	12
Aneura	76	17	38	
Asplancna			4	
Polyarthra				
Noltholca	4.2	4		
Hexarthra	4.2			
Daphnia				1.6
Diaptomus	5.6	4	3.2	3.2
Cyclops	12.8	9.6	1.6	1.6
Nauplii	16	8	1.6	5.6
Corethra	42		1.6	
Melosira	183	213	72	38
Fragillaria	435	226	157	320
Asterionella	4	8	8	
Anabena	25			
Clathrocyctis	686	297	401	234
Oscillatoria	115	29	42	38
Lyngbya	64	149	12	8

Dissolved Gases

D	T	O	%	CO_2	Cb
S	22	5.50			36.34
2	22	5.49			35.34
4	22	5.43			35.34
6	18.2	3.69		3.48	36.34
8	13.7	2.69		3.98	38.34
10	12	2.12		6.96	37.58
12	11	1.99		5.22	38.84
15	10.6	1.68		5.46	39.34
20	8.6	.97		6.22	38.84
25	7.5	.06		7.70	42.42

TABLE 63.

LAKE: SNOW LAKE
Date: 8/14/30

Plankton					Dissolved Gases					
Species	0-5	5-10	10-15	15-20	D	T	O	%	CO_2	Cb
Ceratium	832	80	25	110	S	23.8	5.31		2.2	36.6
Dinobryum	119		4	21	2	23.3	5.22		2.2	36.6
Aneura	68		8.5	21	4	23.3	5.56		1.4	35.8
Polyarthra					6	20	3.87		1.0	35.8
					8	12.2	2.34		1.0	42.0
Daphnia	4.8	3.2		17	10	9.4	2.55		1.0	42.4
					12	8.8	1.50		1.0	42.4
Diaptomus	8.8	88	3.2	6.4	15	8.3	1.31		1.0	42.4
Cyclops	28	18.4	6.4	20						
Nauplii	16	6.4	4	8.8	20	6.8	1.16		1.0	42.4
Melosira	46	64	146	123	24	6.3	.05		4.0	55.4
Fragillaria	115		29	46						
Asterionella										
Anabena										
Clathrocyctis	5,824	1,191	824	1,467						
Oscillatoria	149	128	16	76						
Lyngbya										

TABLE 64.

LAKE: SNOW LAKE

Date: 8/22/30

Plankton

Species	0-5	5-10	10-15	15-20
Ceratium	1,877	337	127	38
Acinetaetis		213	81	
Dinobryum	1,838	349	89	17
Aneura	128	38	17	12
Triarthra	8	25		
Polyarthra	179	68	34	
Asplancna	12			
Noltholca	4			2
Daphnia		2.4	3.2	8
Diaptomus		9.6	4.8	8.8
Cyclops	23	32	5.6	4
Nauplii	36	14.4	4.8	17
Corethra				.8
Melosira	115	64	162	115
Fragillaria	366	123	123	25
Asterionella				
Anabena	46	89		12
Clathrocyctis	17,412	3,468	806	302
Oscillatoria	456	221	93	162
Lyngbya		75	119	

Dissolved Gases

D	T	O	%	CO_2	Cb
8	22.2	5.03		- .60	13.80
2	22.2	5.69		-2.4	34.8
4	22	5.99		—2.0	35.2
6	21.2	5.92		—1.4	35.4
8	12.7	3.00		2.0	41.6
10	9.8	2.51		1.4	42.0
12	8.9	1.47		2.0	42.2
15	8.3	1.23		1.4	42.0
20	7.2	1.11		2.4	41.4
24.5	6.6	.09		3.0	44.0

TABLE 65.

LAKE: SNOW LAKE
Date: 8/30/30

Plankton

Species	0-5	5-10	10-15	15-24
Ceratium	341	345	64	21
Dinobryum	180	196	132	21
Aneura	42	25	4	
Polyarthra	52	46	8.5	
Daphnia		2.4	6	
Diaptomus	10	6.4	8	1.6
Cyclops	36	16	4	
Nauplii	24	49	4.8	
Melosira	25	30	68	4
Fragillaria	217	320	64	17
Asterionella				
Anabena	8	12		
Clathrocyctis	5,004	1,612	935	614
Oscillatoria	324	345	196	59
Lyngbya	55	1,207	72	

Dissolved Gases

D	T	O	%	CO_2	Cb	pH
S	22.7	6.50	108	—1.4	35.0	8.3
2	22.8	6.47	108	—2.2	35.2	
4	22.2	5.91		—2.4	34.4	
6	20.6	4.85		0	45.8	
8	12.2	2.50		1.4	44.0	
10	9.5	1.60		2.0	41.6	
12	8.8	1.10		1.4	42.6	
15	8.3	.95		1.4	43.8	
20	7.2	.92		3.4	43.0	
24.5	6.6	.05		3.4	45.4	7.5

TABLE 66.

LAKE: SNOW LAKE
Date: 9/2/30

Plankton					Dissolved Gases					
Species	0-5	5-10	10-15	15-24	D	T	O	%	CO_2	Ch
Difflugia	38	17	8							
Ceratium	1,400	469	200	55	8	20.2	5.40		0	35.8
Uroglea	247	12								
Dinobryum	1,156	204	85	42	2					
Mallomonas	836	162	38							
Aneura	153	38	29	25	4					
Polyarthra	102	8			6	20	5.44		0	35.8
Triarthra	21				7	18.3				
Noltholca		4.2			8	16.3	2.70		-1.50	36.8
					9	11.1	.42		3.02	41.4
Daphnia	.8			5.6	10	10	.63		4.52	41.8
Bosmina	.8				12	9.4	.42		3.02	41.8
					15		.11		4.02	42.4
Diaptomus	.8	12	3.2	1.6						
Cyclops	12.8	55	12.8	11.2						
Nauplii	16.8	27	8	8.8	20		.06		4.52	42.4
Corethra				1.6						
Melosira	128	115	81	89	24.5	6.7				
Fragillaria	7,436	1,416	430	17						
Asterionella										
Anabena	238	149		4						
Clathrocyctis	1,587	473	1,320	115						
Oscillatoria	793	349	45	16						
Lyngbya	499	281	13	76						

TABLE 67.

LAKE: SNOW LAKE
Date: 9/7/30

Plankton					Dissolved Gases					
Species	0-5	5-10	10-15	15-20	D	T	O	%	CO_2	Cb
Difflugia			4.2	17						
Ceratium	1,011	456	123	30	S	22.2	5.45		—1.4	33.8
Uroglea	951	217	6.4	1.7						
Dinobryum	399	81	17	4.2	2	21.6	5.58		—3.2	34.2
Mellomonas	512	55	55	12						
Aneura	179	12.8		8.5	4	21.9	5.40		—1.4	33.8
Polyarthra	42	29.8			6	20.3	4.66		— 4	34.8
Triarthra	17	8.5								
					8	13	1.87		1.4	40.8
Daphnia		1.6	4	4	10	10	1.37		1.8	40.8
Ostracod				.8	12	8.9	.70		1.6	42
					15	8.3	.50		2	41.6
Diaptomus	3.2	4.8	8	1.6						
Cyclops	21.6	26.4	11.2	1.6						
Nauplii	36	24	6.4	4.8	20	7.3	.62		2.4	42
Corethra			.8							
Melosira	59	115	217	85	24	6.6	.09		2.2	44
Fragillaria	311	477	159	29						
Asterionella										
Anabena	119	85		17						
Clathrocyctis	247	421	571	166						
Oscillatoria	328	324	294	123						
Lyngbya		960	793	55						

TABLE 68.

LAKE: TURKEY (Big) (LaGrange and Steuben)
Date: 8/18/30

Species	0-5	5-10	10-15	15-20	D	T	O	%	CO_2	Cb
	Plankton				Dissolved Gases					
Ceratium	1,105	157			S	23.5	4.70		—1.6	33.8
Dinobryum	1,177	64			2	23.4	5.07		—2.0	34.6
*	25									
Aneura	123	8.5			4	23.3	5.19		—1.4	33.4
Hexarthra	8.5									
Polyarthra					6	18.3	2.61		0	38.8
Noltholca	8.5	4.2								
					8	12.5	.21		.4	46.8
Daphnia	20	8			10	11.5	.10		.4	46.8
					12.5	11.1	.08		.4	49.0
Diaptomus	14	3.2								
Diaptomus	14	3.2								
Cyclops	16	4								
Nauplii	115	12.8								
Melosira	951	358								
Fragillaria	21									
Asterionella	12									
Anabena	21	8								
Clathrocyctis	166	166								
Oscillatoria	1,122	302								
Lyngbya		34								

TABLE 69.

LAKE: NORTH TWIN
Date: 9/2/30

Plankton					Dissolved Gases						
Species	0-5	5-10	10-15	15-20	D	T	O	%	CO_2	Cb	pH
Ceratium	495	98			8	23.8	6.16	105	—3.0	31.0	8.2
Dinobryum	861	209			2	23.8	6.13	104	—3.0	31.0	8.2
Aneura	72	46			4	23.3	6.36	107	—2.8	31.4	8.2
Polyarthra	81	8			6	21.3	5.50		—1.0	31.4	8.2
Noltholca		38			8	15.5	.41		0	38.2	7.5
Daphnia	6.4				11	12.2	.32		1.0	21.6	7.4
Diaptomus	24	4									
Cyclops	15	4.8									
Nauplii	21										
Melosira	34	76									
Fragillaria	1,501	631									
Asterionella											
Anabena	25	25									
Clathrocyctis	1,280	678									
Oscillatoria	76	640									
Lyngbya		115									

TABLE 70.

LAKE: SOUTH TWIN
Date: 9/2/30

Plankton

Species	0-5	5-10	10-15	15-20
Ceratium	482	162	42	
Dinobryum	55	16	17	
Aneura	46	68	25	
Polyarthra	166	42	8	
Noltholca			12	
Daphnia	5.6	4		
Diaptomus	17	11.2	2.4	
Cyclops	57	24	6.4	
Nauplii	44	12	5.6	
Melosira	34	89	38	
Fragillaria	349	243	101	
Asterionella		12		
Anabena	55	106	12	
Clathrocyctis	712	307	200	
Oscillatoria	230	153	46	
Lyngbya	4			

Dissolved Gases

D	T	O	%	CO_2	Cb
S	23.8	6.25	106	-3.2	29.8
2	23.8	6.18	105	—2	29.6
4	23.3	6.18	104	—2.4	29.8
6	21.66	6.26	102	-2.0	30.0
8	19.4	6.12		0	36.8
10	11	1.86		1.0	38.4
12	9.4	.38		1.2	39.6
15	9.1	0		1.6	44.4

TABLE 71.

LAKE: WALLEN LAKE
Date: 8/24/30

Plankton					Dissolved Gases						
Species	0-5	5-13	10-15	15-20	D	T	O	%	CO_2	Cb	pH
Ceratium	1,361	341			8	23.4	5.69		—2.0	39.4	8.3
Difflugia	81	25									
Dinobryum	4	4			2	22.3	5.67		—1.4	39.6	8.2
*	136										
Aneura	153	34			4	22.2	5.68		—2.0	39.4	8.2
Polyarthra					6	16.9	23.8		1.0	50.0	7.7
Hexarthra	21	4									
Noltholca		4			8	11.9	0		2.4	51.0	7.7
Daphnia	13.6	5.6			10	11.1	0		4.0	51.0	7.1
Diaphonosona	6.4										
					13.5	10.5	0		.2	52.4	7.1
Diaptomus	13.6	.8									
Cyclops	56	12									
Nauplii	110	29									
Corethra		102									
Melosira	4,906	541									
Fragillaria	183	29									
Asterionella	12										
Anabena	208	63									
Clathrocyctis	2,338	2,453									
Oscillatoria	780	294									
Lyngbya	59	3,366									

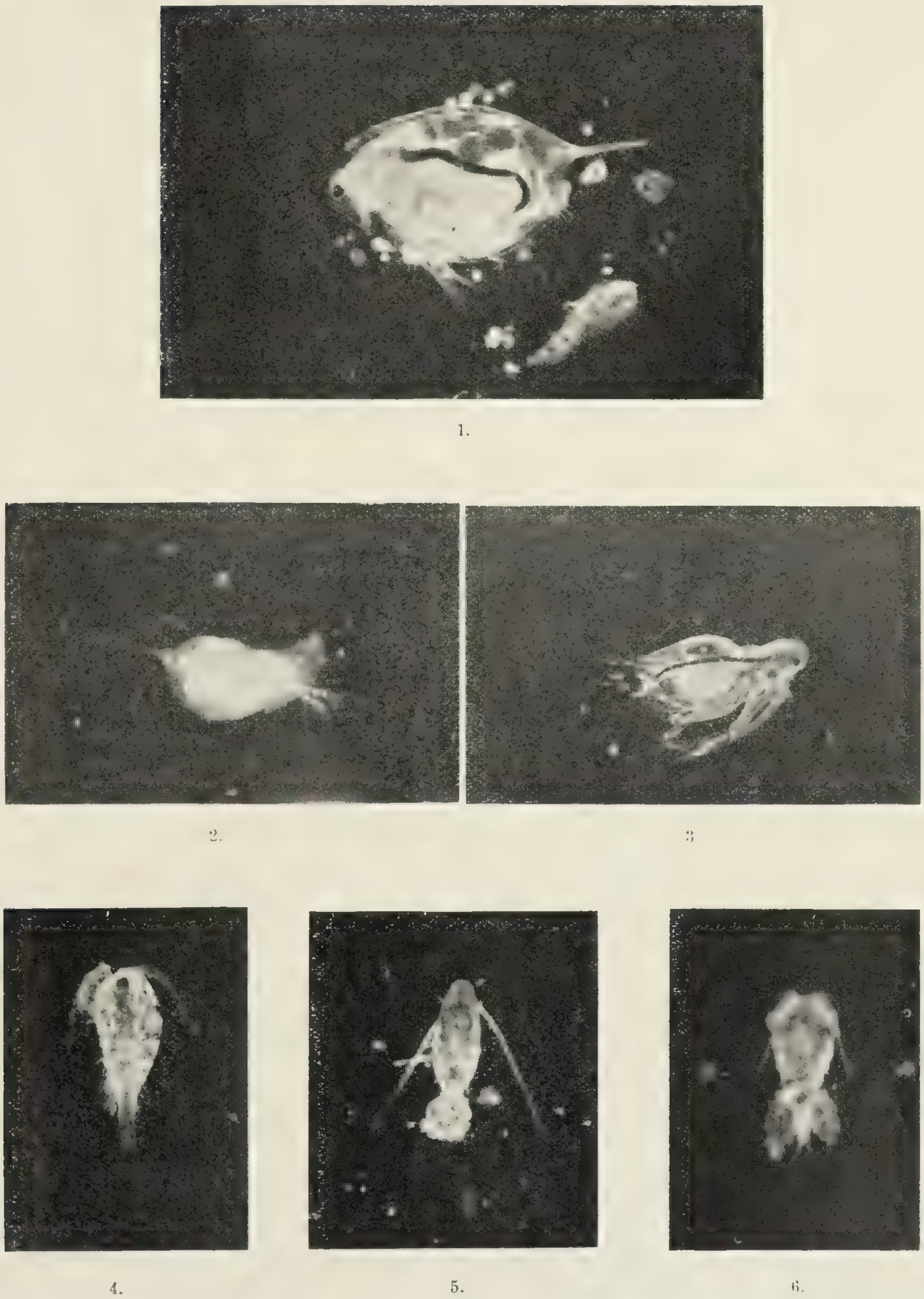

FIG. 4. Small crustacea used as food by fish. Photographs taken with a dark field condenser. 1. Daphnia pulex; 2. Daphnia retrocurva; 3. Diaphanosoma; 4. and 6. Cyclops; 5. Diaptomus.